PB 207 146

ECONOMIC IMPACT OF ANTICIPATED PAPER INDUSTRY POLLUTION – ABATEMENT COSTS

PART III: ECONOMIC ANALYSIS

report to

THE COUNCIL ON ENVIRONMENTAL QUALITY

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

Arthur D. Little, Inc.

10

ECONOMIC IMPACT OF ANTICIPATED PAPER INDUSTRY POLLUTION ABATEMENT COSTS

PART III

ECONOMIC ANALYSIS

Report To

THE COUNCIL ON ENVIRONMENTAL QUALITY

73977

November 1971

Arthur D. Little, Inc.

TABLE OF CONTENTS

PART III

		Page
I.	**INTRODUCTION**	1
	A. Purpose and Scope	1
	B. Approach	1
II.	**CAPITAL AND OPERATING COSTS TO MEET ANTICIPATED POLLUTION ABATEMENT REQUIREMENTS**	3
	A. Water Pollution Control	3
	B. Sulfite Pulp Liquor Treatment and Chemical Recovery Systems	5
	C. Other Pulp Mills	9
	D. Air Pollution Control	9
	E. Total Industry Capital Requirements 1972-1976	11
	F. Summary of Water and Air Pollution Costs for Marginally Sized Mills	12
III.	**DIRECT ECONOMIC IMPACT ON THE PULP AND PAPER INDUSTRY**	15
	A. Prices	15
	B. Mill Shutdown Probabilities	15
	C. Employment	42
	D. International Competitiveness	46
IV.	**INDIRECT ECONOMIC IMPACT**	49
	A. Effect on Supplier Industries	49
	B. Effect on Customers	53
	C. Effect on Balance of Payments	54

I. INTRODUCTION

A. PURPOSE AND SCOPE

The purpose of this part of our report to the Council on Environmental Quality is to analyze the specific dislocations and changes that are anticipated as a result of the increased capital and operating costs the paper industry will face in complying with the water and air pollution limits anticipated over the next five years. This analysis draws on the description of the industry structure and trends in supply/demand and profitability provided in Part II of our report. This section, Part III, is mainly statistical in nature. For a summary of our findings and conclusions, see Part I.

B. APPROACH

The information contained in this report is based primarily upon our background knowledge developed through our consulting experience in the paper industry plus data developed from a number of sources during this analysis. Specifically, we called upon key staff members of the American Paper Institute Divisions for tissue papers, printing and writing papers and paperboard to review and critique our selection of each of the marginal mills in these industry sectors. We also contacted officers of firms within these sectors and within the special industrial paper, insulation board, construction paper and semi-chemical corrugating medium product sectors. All of the above sectors were found to contain a relatively large number of marginal mills and to have experienced severe financial problems in 1970 and, in most cases, in 1971; therefore they are likely to have the greatest economic difficulty in meeting the anticipated pollution standards. Through our contacts we sought to cross-check our analysis of potential dislocations within these sectors and to obtain data from a number of mills that would serve to characterize the financial performance of typical marginal mills in each sector. We are indebted to the companies that provided us with this information; to safeguard their interests we have pledged to maintain the strictest confidence on individual company data.

We called upon our own specialists in water and air pollution control to analyze the capital and operating costs anticipated over the next five years. They drew upon: data contained in the report "Control of Atmospheric Emissions in the Wood Pulping Industry" (U.S. Department of Commerce, E.R. Hendrickson, et. al), EPA pollution cost data, information from the National Council of the Paper Industry for Air & Stream Improvement, Inc. and ADL files on specific mill cost experience.

These data were then applied to the gaseous and water emissions associated with each major type of pulp and papermaking process to calculate the

anticipated capital and operating costs for each. This information was cross-checked with key staff members of the National Council of the Paper Industry for Air & Stream Improvement, Inc. We found that our cost estimates generally fell close to the median of those provided for the purpose of the study by the Environmental Protection Agency; we felt, however, that the EPA data were not specific enough for our detailed product sector analysis and that a narrower range of uncertainty could be placed around our estimates (typically ± 20%). Our cost estimates are provided in Chapter II and Appendices A and B.

We then reflected our pollution abatement cost estimates against current prices of pulp and paper products and expected profitability levels of marginal firms to assess the impact on price increases and mill shutdowns. The impact on mill dislocations was compared against estimated mill closures that would occur without any additional pollution abatement expenditures above current levels. The difference represents the anticipated capacity removal due to problems associated with obtaining the required capital and incurring the operating costs associated with anticipated pollution control requirements through 1976. The estimates of net production tonnage removed were then utilized to reflect the number of jobs that would be lost in each major region of the country due to the economic impact of pollution control requirements. These direct impacts are discussed in Chapter III.

Finally, we called upon a number of our specialists in industries related to the pulp and paper industry to analyze the impact of the anticipated pollution abatement requirements on these industries. These and other indirect impacts are discussed in Chapter IV.

II. CAPITAL AND OPERATING COSTS TO MEET ANTICIPATED POLLUTION ABATEMENT REQUIREMENTS

A. WATER POLLUTION CONTROL

The treatment of wastewaters from the pulp and paper industry will encompass an increasing number of operational steps and procedures because the quality of the effluent must be improved. From long experience with the treatment of wastewater, we recognize that the presently most economical approaches will be based on physical removal of the suspended solids matter and the conversion of soluble biological oxygen demanding substances (BOD) into biological organisms which can then be separated for disposal. Of course, a large number of variables in equipment and operation can be applied to achieve the required cleanup; for industry-wide economic considerations, however, it is possible to develop generalized capital and operating costs for a limited number of treatment processes which are currently installed and operating satisfactorily. The wastewaters from the pulp and paper industry are in general readily treated by biological systems if sufficient nutrients in the form of nitrogen and phosphorus are supplied. The removal of color bodies remains a significant problem and our assumption in establishing capital and operating costs is that color removal will not be required by 1976.

For purposes of considering the economic impact of pollution abatement between now and 1976, we have considered only suspended solids removal and BOD reduction as the key parameters in estimating future costs since compliance with other standards (such as pH, temperature, color and alkalinity) either is not universally required, has little effect on costs, or does not have clearly developed solutions available. Our analysis assumed that by 1976 all paper mill effluents would be subjected to both primary and secondary treatment. We further assumed implementation of 95% suspended solids removal in the primary treatment systems, and 90% BOD reduction in the secondary systems.

In order to establish the water pollution abatement costs to the pulp and paper industry we examined the cost estimating model data provided us by the Environmental Protection Agency (EPA) for the various corrective steps (neutralization, flotation, sedimentation, stabilization and incineration) and compared those with data we have for specific mills. Although it was possible to obtain a reasonable agreement between, for example, our estimates of costs for activated sludge treatment plants and the summation of the EPA neutralization, flotation, sedimentation and stabilization costs, we chose to establish a separate estimating procedure which would be more flexible in providing cost estimates for the various product sectors of the industry than appeared possible by the techniques used to establish the costs furnished to us. Furthermore, our procedures allowed us to utilize recent data sources such as unpublished EPA data on

wastewater loads which were unavailable when the EPA mathematical models were developed. By applying this current data to specific treatment processes that have begun to be employed by some mills we believe that a narrower range of uncertainty (generally ± 20%) can be placed around our estimates.

We estimated the capital investment using the Engineering News Record Construction Cost Index of 1550 (1913 = 100; i.e., approximate mid-1971 costs) for primary treatment (solids removal), neutralization, activiated sludge via a conventional plant, and extended aeration via aerated lagoons. Our capital investment estimates were based on the following sources of information:

(1) *The Cost of Clean Water, Volume III, Industrial Waste Profiles: Paper Mills*, (U.S. Department of the Interior, FWPCQ, 1967).

(2) *The Cost of Clean Water and Its Economic Impact, Volume IV: Projected Wastewater Treatment Costs in the Organic Chemicals Industry* (U.S. Department of the Interior, FWPCA, 1970).

(3) *Cost of Conventional and Advanced Treatment of Wastewaters*, (Robert Smith, Cincinnati Water Research Laboratory, EPA; July 1968).

(4) *Cost of Wastewater Treatment Processes, Report No. TWRC-6: Ohio River Basin Region* (EPA, December 1968).

(5) *Advanced Wastewater Treatment*, (Gordon Culp and Roger Culp, D. Van Nostrand, Reinhold Publishing Company, 1971).

(6) *A Survey of Pulp and Paper Industry Expenditures and Accomplishments in Receiving Water Quality Protection Programs: Special Report No. 71-02* (National Council of the Paper Industry for Air and Steam Improvement [NCASI], New York, August 1971).

(7) Arthur D. Little, Inc., files on specific mill experience.

Capital investment costs were established as a function of volumetric flow rates in millions of gallons per day. This procedure is sufficiently accurate because the wastewaters from the pulp and paper industry are treatable by methods involving considerable physical similarities regardless of variations in specific operational requirements. Relationships between capital investments and flow rates, plotted on log-log coordinates, were used for interpolation and extrapolation. (See Appendix A.) Annual costs were established as a function of flow rates for labor, maintenance, amortization and debt services. Interest rates of 10% per year and 20-year amortization factors were used. Annual maintenance

costs were taken as 2% and 4%, respectively, for primary plus activated sludge treatment plants and for aerated lagoons. Operating labor was estimated for three flow sizes and summed with the above costs to provide estimating curves. Electricity and chemical costs per unit of throughput are essentially constant for BOD removal at efficiency levels in the range of interest (estimated to be over 75% but not over 90% for chemicals and 1.5¢ per KWH for electricity amounting to $0.011/lb BOD for activated sludge treatment and $0.015/lb BOD for extended aeration). Land filling of waste sludge was assumed to cost $5.00/dry ton of solids. These costs were translated directly to unit costs for the various paper mill products using standard raw waste loads. Table 1 shows the waste water loads by product sector and Table 2 presents our water pollution abatement cost estimates for all sectors except sulfite and semi-chemical pulps which will be discussed later.

Our calculations indicate that both the capital and operating costs for activated sludge treatment plants are two to three times greater than comparable figures for extended aeration systems. It has been obvious for some time that most mills in the pulp and paper industry will use extended aeration as their principal method of secondary treatment except when the required lagoon area is not available; in these cases, activated sludge plants will be used.

Since extended aeration will be the rule, our cost analysis has focused upon it as the most acceptable processing technique. Our calculations show that the cost of primary and secondary wastewater treatment to meet the above objections will range from a minimum of approximately $3 per ton of product to a maximum of approximately $14 per ton of product depending upon production tonnage, water use and pulp or paper product.

B. SULFITE PULP LIQUOR TREATMENT AND CHEMICAL RECOVERY SYSTEMS

The sulfite pulping and recovery processes are substantially more complex than kraft in terms of the alternative chemical systems and methods employed in making the pulp and processing the waste liquor. Therefore, we have treated the abatement problem separately in this section. Sodium, ammonia and magnesium are employed as alternative bases in the chemical system mixed with sulfur to form sulfite. The chemistry provides for recovery for both sulfur and base in certain instances, but in others a waste treatment plant (producing a by-product) must be employed instead of a recirculating recovery system.

Table 3 summarizes the capital and operating costs for the various pollution abatement systems which may be adapted to the sulfite pulping industry. Appendix B provides the graphs and details employed in making these estimates.

TABLE I

STANDARD UNTREATED RAW WASTE WATER LOADS IN THE PAPER INDUSTRY

TABLE

	HYDRAULIC LOAD, 1000 GAL/ TON OF PAPER	BOD LOAD LB/TON OF PAPER	SUSPENDED SOLIDS LOAD LB/TON OF PAPER
1. NEWSPRINT & UNCOATED GROUNDWOOD PAPER	60,000	120	140
2. COATED PRINTING, WRITING AND FINE PAPER (1)	30,000	50	50
3. UNBLEACHED IND. & CONV. PAPERS	40,000	50	70
4. TISSUE PAPER (1)	30,000	50	50
5. UNBLEACHED KRAFT BOARD	40,000	50	70
6. S.C. CORRUGATING			
WITH CROSS RECOVERY	10,000	60	40
WITHOUT RECOVERY	15,000	500	80
7. BLEACHED BOARD	65,000	100	90
8. COMBINATION BOARD INCL. (1) JUTE LINER & BOGUS MOD.	12,000	30	40
9. BUILDING PAPER (1)	10,000	10	10
10. INSULATION BOARD (1)	10,000	150	200
11. HARDWOOD (1)	12,000	200	100
12. BLEACHED KRAFT PULP	65,000	100	90
13. BLEACHED SULFITE PULP (NO RECOVERY)	100,000	1200	60
14. UNBLEACHED SULFITE PULP (NO RECOVERY)	80,000	1200	50
15. GROUNDWOOD PULP	5,000	50	60
16. DEINKING	30,000	90	800

(1) NOT INTEGRATED TO PULPING

Source: Arthur D. Little, Inc., estimates

Arthur D Little Inc

TABLE 2

PRIMARY AND SECONDARY WATER TREATMENT COSTS FOR PULP AND PAPER PRODUCTS (EXCEPT SULFITE PULP)

	Mill Production Capacity (2) (tons/day)	Waste Water Load 10^6 gal/day	Annual Operating Costs (3) $ Million (Except Power and Chemicals) Activated Sludge	Annual Operating Costs (3) $ Million (Except Power and Chemicals) Aerated Lagoons	Cost per Ton of Product (Dollars) Power & Chemicals Activated Sludge	Power & Chemicals Aerated Lagoons	Sludge Disposal	Total Costs Activated Sludge	Total Costs Aerated Lagoons
Newsprint and Groundwood	200	12.00	2.00	0.80	1.32	1.80	0.85	29.90	13.20
Printing and Writting (1)	125	3.85	0.85	0.43	0.55	0.75	0.20	20.20	10.50
Unbleached Industrial and Converting	125	5.00	1.05	0.33	0.55	0.75	0.30	24.80	8.30
Tissue Paper (1)	75	2.25	0.60	0.30	0.55	0.75	0.20	23.60	12.20
Unbleached Kraft Board	350	14.40	2.20	0.70	0.55	0.75	0.30	20.00	6.50
Semi-Chemical Corrugating									
(a) With Cross Recovery	250	2.50	0.65	0.25	0.66	0.90	0.20	8.30	3.80
(b) Without Recovery	250	3.75	0.85	0.35	5.50	7.50	1.45	16.60	11.50
Bleached Board	300	19.50	2.80	0.85	1.10	1.50	0.45	28.20	9.70
Combination Board (1)	100	1.20	0.38	0.20	0.33	0.45	0.15	11.30	6.20
Building Paper (1)	75	0.75	0.275	0.15	0.11	0.15	0.05	10.70	5.90
Insulation Board (1)	100	1.00	0.33	0.17	1.65	2.25	0.85	12.00	7.10
Hardboard (1)	100	1.20	0.38	0.20	2.20	3.00	0.70	13.80	8.70
Bleached Kraft Pulp	600	39.00	4.70	1.30	1.10	1.50	0.45	23.80	7.70
Groundwood Pulp	150	0.75	0.275	0.12	0.44	0.60	0.25	5.90	2.90
Deinking	50	1.50	0.45	0.22	0.99	1.35	2.20	28.90	13.80

(1) Not integrated to pulping.
(2) These mill sizes establish the upper end of the range which we consider to be marginal by current standards.
(3) See Appendix A, Figure A-1, for cost bases.

Source: Arthur D. Little, Inc., estimates.

Arthur D Little Inc

TABLE 3

SULFITE PULP WASTE LIQUOR TREATMENT AND CHEMICAL RECOVERY
CAPITAL AND OPERATING COST RANGES[1]

Cooking Liquor Base	Pulp Yield (%)	Fixed Capital Investment ($000 per Ton/Day) Pulp Mill Capacity (Unbleached Tons/Day) 100	700	Operating Cost ($ per Ton Pulp) Pulp Mill Capacity (Unbleached Tons/Day) 100	700
Sodium[2]	48	13	7	16.70	8.80
	72	8	4	11.70	4.80
Ammonia	44	35	21	11.80	0.50
	72	24	15	12.50	3.00
Magnesium	47	43	25	8.10	(8.10)[3]
	60	36	21	15.00	0.10

(1) Mid 1971 Capital and Operating Costs

(2) Na_2SO_4 by-product

(3) Credit

Source: Arthur D. Little, Inc., estimates

The capital investment requirements for these recovery and liquor treatment systems range from a low of about $5,000 per daily ton of capacity to a high of $40,000–45,000 per daily ton of pulp capacity, with total operating costs ranging from a maximum of approximately $17 per ton of pulp for fluid bed incinerators operating on small sodium-based, low-yield pulp mills to a net chemical recovery credit of about $8 per ton of pulp for fully cooked magnesium bisulfite pulp.

Considerable care should be employed in using these unit costs and net credit figures since the conversion of a sulfite pulp mill from a polluting one to a non-polluting one often entails a change in the base chemical. It is important to note that pulps made with the various base chemicals are not of equal quality and value and it is virtually impossible to work the economics of this relationship into the equations associated with the cost of chemical recovery. For example, a sodium base sulfite mill might convert to magnifite pulping in order to achieve relatively low cost recovery economics at the expense of pulp quality and product value. Alternatively, the continued use of sodium base pulping with the relatively high liquor treatment costs associated with that base might prove to be more acceptable based on the particular company's needs in papermaking. In general, sulfite pulp producers can be expected to have to pay an additional $10 per ton of pulp in order to accommodate liquor treatment and this is the basic cost factor we have employed in our analysis. The low figures are for large magnefite mills with chemical recovery. Conversely, the highest figure is for the sulfite component in newsprint, where low sulfite pulp throughput contributes to the high cost of waste treatment.

C. OTHER PULP MILLS

We have calculated the cost of wastewater treatment from bleached kraft pulp and from groundwood pulp and the de-inking of waste fibre. Waste treatment from groundwood pulp is estimated to be about $3 per ton of pulp, principally because water use is very low (5,000 gallons per ton). We calculate the cost of wastewater treatment from bleached kraft market pulp operations at $7.70 per ton of pulp and for waste treatment from de-inking operations at $14 per ton of pulp.

D. AIR POLLUTION CONTROL

1. Kraft Mills

The kraft pulp mill and recovery plant are by far the most important sources of air pollution in the pulp and paper industry. In our cost analysis we have assumed that the air pollution regulations tentatively adopted by the state of Oregon will be observed by all U.S. kraft mills by 1976. The Oregon regulations

stipulate that the maximum discharge of particulate matter will be less than four pounds per air dry unbleached ton of kraft pulp and that the maximum discharge of reduced sulfur gases will be less than 10 parts per million (dry basis) in the tail gas.

Several combinations of process alternatives may be implemented to reduce gaseous emissions from kraft mills. The cost effectiveness of these technical alternatives is not clearly understood nor is their technical practicality. Equipment suppliers and interested members of the industry are undertaking studies to determine the best courses of action, keeping in mind manufacturing efficiencies and pollution abatement effectiveness. At this point in time it is premature to attempt to judge the cost effectiveness of these possibilities and therefore the ultimate cost of air pollution control on the kraft pulping industry.

As a result, the capital cost of air pollution control in the kraft pulp industry is far from being a clearly defined subject. There have been many articles written and data developed indicating that the capital cost of add-on systems normally anticipated can total approximately $2500 per daily ton of pulp capacity. On the other hand, we have reliable recent data from a specific mill (and one which has a relatively bad pollution problem) where the total capital cost to achieve the above objectives will be only $1300 per daily ton of pulp capacity. In addition, there is the very complicated issue of the replacement of existing kraft recovery boilers with new boilers, part of which is assignable to pollution control. Reductions in pulp production rates are also likely to occur in many instances of air clean-up, and the incremental cost associated with these lower tonnage rates can also be assigned to pollution control.

It is also impossible to develop any great accuracy with respect to the operating costs associated with pollution abatement. On the lower end of the spectrum, we would judge that the total cost might be about $1.50 per ton of kraft pulp. On the other hand, substantially higher figures are reported and figures of $3 or $4 per ton of pulp can easily be claimed.

Until the technology is more properly understood and the choice of process systems more clearly delineated, it will be impractical to attempt greater refinement of either the capital or operating cost figures associated with air purity control in the kraft pulping industry.

2. Sulfite Pulp Mills

As chemical recovery and liquor treatment systems are applied to sulfite pulp mills, they will result in new increments of air pollution from the incineration processes employed and from the volatile sulfur gases which already constitute a problem. However, the technology for solving these problems is

relatively simple: recycle of the volatile gases back to the process, and the institution of wet scrubbers for the abatement of particulate emissions. We expect that the capital costs for the add-on devices will average $200 per daily ton of pulp capacity, resulting in an incremental operating cost (including the depreciation and interest charges) of $0.75 to $1.00 per ton of pulp produced.

3. Power Boilers

For the most part power boilers in the pulp and paper industry are already converted from coal firing to No. 6 fuel oil. In order to put these boilers into compliance with air pollution regulations, they will be fired with low sulfur fuels, resulting in a substantial increase in the cost of steam and power and, in many cases, requiring that tail gases be purified before being discharged into the atmosphere in order to reduce particulate emissions. We estimate that the capital cost for these boiler conversions will total approximately $700 per daily ton of paper or board capacity, and taking into account the incremental cost of low-sulfur fuel, will raise the cost of paper and board production by about $1 per ton.

E. TOTAL INDUSTRY CAPITAL REQUIREMENTS 1972-1976

In estimating the paper industry's capital requirements to achieve the air and water pollution standards anticipated by 1976, one must consider the abatement levels already achieved by the industry. On the water side many mills have already implemented in-plant waste control measures; many have primary treatment facilities (about 70% of the mills, about 90% of the tonnage), and far fewer employ secondary treatment (perhaps 40% of the mills or 60% of the tonnage). Since a substantial portion of the capital costs for water treatment lie in secondary treatment facilities, the industry has yet to spend over 50% of the capital costs associated with meeting the level of control anticipated by 1976.[1]

On the air side there is nearly universal use of electrical precipitators to control particulate emissions in U.S. pulp and paper mills. However, very few mills are now achieving 90% particulate removal. Since the capital (and operating costs) escalate very rapidly as 90% removal is approached, we can say that most of these costs have yet to be incurred. Very few mills are currently controlling kraft pulp mill reduced sulfur emissions although many are making plans to do so. Thus for all intents and purposes, this cost has yet to be incurred.

---

(1) The above percentage estimates of mills with primary and secondary treatment are derived from a recent mill survey by NCASI. These figures may be misleading as to the degree of accomplishment to date for two reasons: not all mills in the industry responded, nor is the degree of pollution reduction known for existing installations. Thus, remaining costs for 95% suspended solids removal and 90% BOD reduction in secondary systems may be far in excess of the 50% estimate.

Table 4 recapitulates the average capital costs for air and water pollution control in the various pulp, paper and product sectors of the industry. The figures are reported on a unit basis (capital dollars per daily ton of throughput) with the figures in the water column accounting for primary and secondary biological treatment of all aqueous wastes from the various manufacturing operations. The air column provides for air pollution abatement except for power boilers, which are covered separately, and a liquor treatment column accounts for sulfite systems only.

In this way, taking into account those product sectors of the industry which are integrated and also those which are not, we are able to total the unit costs and then convert these into total capital dollars to be expended by 1976 based on the anticipated production tonnage in the various product categories at that time. By this mathematical exercise we have calculated that the total expenditure to abate pollution from a point of no primary or secondary treatment in the industry to anticipated levels of treatment by 1976 (taking into account growth during that period) will total $4.1 billion, approximately $800 million of which will be in air pollution control and approximately $3.3 billion of which will be in water pollution control.(1) Approximately $800 million of this total has already been invested through 1971, leaving a balance of $3.3 billion.

F. SUMMARY OF WATER AND AIR POLLUTION COSTS FOR MARGINALLY SIZED MILLS

In Table 5 we have prepared specific capital and operating cost data for water pollution controls applied to the most sensitive product sectors of the industry at low tonnage levels where the difficulties will be most acute. In these product categories (tissue, special industrial, printing and writing, and combination paperboard) the operating costs of water pollution control range from $8 to $25 per ton of product with capital costs ranging from $16,000 to $51,000 per daily ton of capacity. These costs are substantially higher than those of larger mills.

To these figures can be added air pollution control requirements associated with modifying the power boilers typically used by this sector of the industry. These figures amount to approximately $1 per ton of product for operating expenses and $700 per daily ton of capacity for capital improvements.

---

(1) Here again, it should be noted that these figures are at variance with survey figures provided by the industry. For example, industry estimates indicate $800 million will have been spent for water treatment by 1972, with about $200 million to be spent per year to 1976, or a total of $1.6 billion. The difference may be accounted for in several ways: overstatement by the industry of the degree of primary and secondary treatment now installed, industry underestimation of degree of BOD removal by secondary treatment ultimately to be required – (up to 90%), and overstatement of total capacity by 1976.

TABLE 4

PAPER INDUSTRY CAPITAL COSTS OF AIR AND WATER POLLUTION CONTROL

Product	Dollars Per Daily Ton					Estimated 1976 Daily Capacity (000 tons)	Total Industry Cost 1976 ($million)*
	Water	Air	Liquor	Boilers	Total * Cost		
Newsprint & Groundwood	23,000	2,000	--	1,000	26,000	18	470
Printing, Writing & Related	16,000	--	--	1,000	17,000	35	560
Unbleached Industrial & Converting	20,000	--	--	1,000	21,000	15	320
Bleached Packaging	22,000	2,000	--	1,000	25,000	4.3	110
Tissue	18,000	--	--	1,000	19,000	15	280
Unbleached Kraft Board	13,000	2,000	--	1,000	16,000	38	610
Semi-Chemical Medium	9,000	1,000	--	1,000	11,000	14	150
Bleached Board & Bristols	22,000	2,000	--	1,000	25,000	17	430
Combination Board & Wet Machine	10,000	--	--	1,000	11,000	28	310
Construction Paper	9,000	--	--	1,000	10,000	6.5	65
Insulation Board	9,000	--	--	1,000	10,000	6.1	60
Hardboard	8,000	--	--	1,000	9,000	7.6	70
Bleached Kraft Market Pulp	16,000	2,000	--	--	18,000	10.	180
Sulfite Pulp	--	1,000	20,000	1,000	22,000	6.9 **	150
NSSC Pulp	--	1,000	20,000	1,000	22,000	9.1 **	200
Groundwood Pulp	--	--	--	--	4,000	15	60
De-inked Pulp	--	--	--	--	20,000	3.0	60
					Total		4,085

* In 1971 dollars

** Reflects current capacity without liquor recovery systems plus anticipated expenses and less anticipated removals.

Source: Arthur D. Little, Inc., estimates

TABLE 5

SUMMARY OF WATER POLLUTION COSTS FOR MARGINALLY SIZED MILLS

Product	Tonnage Level TPD	Operating Cost (1) $/Ton of Product	Capital Cost $/Daily Ton Of Capacity
Tissue	20	18	45,000
Special Industrial	15	25	51,000
Printing and Writing	50	18	42,000
Combination Paperboard	50	8	16,000

(1) Based on extended aeration

Source: Arthur D. Little, Inc., estimates

III. DIRECT ECONOMIC IMPACT ON THE PULP AND PAPER INDUSTRY

A. PRICES

To determine the price increases necessary to absorb the increased pollution abatement costs anticipated by 1976, we have compared the abatement costs for efficient mills with the approximate median price of each major product group. We have utilized the abatement costs for efficient mills since these will generally set the price ceiling for the entire industry. We have already discussed the abatement cost levels for marginal mills in Chapter II. In most cases, their costs will be appreciably higher than those of larger mills since the latter benefit from scale economies; this factor adds to the economic difficulties of the marginal mills. Table 6 shows our analysis of the price effect on each major product sector.

Table 6 indicates that the major price increases relative to current prices will be in hardboard, newsprint and groundwood paper, bleached kraft pulp and unbleached kraft linerboard. Here the price increases range from 6.5 to 10% of product value, depending upon the grade. Product sectors that will experience moderate price increases ranging from 3.5 to 6% of current product value are: bleached paperboard, semi-chemical corrugating medium, bag and wrapping papers, combination paperboard, insulation board, printing papers and dissolving pulp. The other product sectors will require only modest price increases.

While several hardboard and insulation board producers employ dry processes, we do not believe that they control enough volume or have any incentive to hold prices down. We anticipate that all of the above price increases will be obtained in the absence of regulated price controls because of the tightening supply/demand balances projected for most sectors in 1972 and 1973. (See Part II.) In most sectors significantly higher price increases than those reflected in Table 6 are anticipated by 1974. Beyond 1974, prices might well decline again should the industry enter another cycle of overcapacity.

B. MILL SHUTDOWN PROBABILITIES

In this section we have concentrated upon the product sectors and mills that will have the greatest difficulty in either raising the capital or absorbing the operating costs associated with the anticipated pollution abatement standards. These key impact areas which were selected in the overall industry analysis in Part II are: sulfite and semi-chemical pulps, tissue paper, printing and writing paper, special industrial paper and combination paperboard. In addition to these sectors, we expect some dislocations to occur to a lesser extent in a variety of other product sectors; these are analyzed in the last part of this section.

TABLE 6

PRICE IMPACT OF ANTICIPATED POLLUTION ABATEMENT COSTS

Key Grades	Approximate Current Price ($/Ton)	Estimated Abatement Cost For Efficient Mill ($/Ton)	Cost As % of Current Price
Unbleached Kraft Liner	120	8.50	7
Bleached Paperboard	210	12.00	6
Semi-chemical Medium	104	5.50	5.5
Combination Paperboard	110	5.50	5
Unbleached Bag and Wrapping	160	8.50	5.5
Bleached Packaging Paper	200	11.00	5.5
Newsprint	160	12.50	8.5
Uncoated Groundwood	180	12.50	7
Coated Publication	220	8.50	4
Uncoated Book	220	8.50	4
Tissue Paper (Converted)	400	8.50	2
Special Industrial Paper	600	9.50	1.5
Construction Paper (shingles)	65	1.00	1.5
Insulation Board	135	6.00	4.5
Hardboard	80	7.50	10
Bleached Kraft Pulp			
Hardwood	120	10.00	8.5
Softwood	150	10.00	7
Dissolving Pulp	220	7.50	3.5

Source: Arthur D. Little, Inc., estimates

1. Sulfite, Semi-chemical and Dissolving Pulp

In Tables 7 and 8 we report the total number and criteria for selection of marginal sulfite and dissolving pulp mills in the various sections of the country. In our view there are 12 marginal mills amounting to an annual capacity of 500,000 tons of sulfite pulp, and we feel that pollution abatement will result in the closure of 9 of the 12 mills, reducing the annual production of sulfite and dissolving pulp grades by 350,000 tons per year. Most of the impact of this change will be felt in the North Central region of the country, but with close-downs anticipated in New England and the West as well. As a result of these mill closures, approximately 13% of the United States domestic supply of sulfite pulp will be removed from the market.

In Table 9 we report anticipated marginal capacity shutdown factors in semi-chemical pulping. In our judgment there are nine marginal mills producing 250,000 tons per year of semi-chemical pulp, a very high percentage of which is ultimately converted into corrugating medium. Based on pollution abatement requirements, we foresee the closure of five semi-chemical pulp mills whose total tonnage amounts to 135,000 tons per year. Most of these closures will occur in the North Central region. The removal of 135,000 tons per year of semi-chemical pulp from the domestic supply will result in a reduction in that supply of approximately 15%. We do not foresee a diminution in the production of corrugating medium per se. Alternatively, we anticipate a greater use of secondary fibre in this product as marginal semi-chemical pulp mills are closed and pressures for use of recycled fibers increase.

Both sulfite and semi-chemical pulp face substantial competition from other pulp sources within the industry: sulfite by substitution from kraft, and semi-chemical by substitution from secondary fiber such as corrugated clippings.

Whereas the exposure of sulfite pulp compared with semi-chemical pulp is somewhat greater and therefore the future of sulfite is somewhat more tenuous, the future of both products represents a borderline situation.

Sulfite pulp in particular has been decreasing in supply over many years as the higher quality (and higher priced) kraft pulps have supplanted sulfite in order to keep pace with increasing product quality demands. Notwithstanding this factor certain properties of sulfite give it advantages over kraft in specific product applications, and particularly in mills integrated to papermaking. Were it not for the pollution cost factors we feel that further reductions in sulfite capacity below existing levels would not likely come about.

On the other hand, nearly all semi-chemical pulp goes into corrugated medium, a product with an assured long-term growth and substantially less

TABLE 7

SULFITE PULP

	No.	tpd
Total Mills	37	9,750
OK	25	8,365
Marginal	12	1,395

MARGINAL CRITERIA:

1. No recovery or inadequate recovery facilities
2. Mill capacity less than 150 tpd
3. Wood species limitation
4. Product value

Marginal Mills

Area	No.	tpd
New England	3	455
Middle Atlantic	0	0
East North Central	5	495
West North Central	1	115
South Atlantic	0	0
East South Central	0	0
West South Central	0	0
West (including Alaska)	3	330
Total	12	1,395

Able-to-Cope Mills

Area	No.	tpd
New England	2	915
Middle Atlantic	3	785
East North Central	6	1,030
West North Central	0	0
South Atlantic	1	400
East South Central	0	0
West South Central	0	0
West (including Alaska)	13	5,225
Total	25	8,365

Source: Arthur D. Little, Inc. estimates

TABLE 8

SULFITE PULP MILL SHUTDOWN PROBABILITIES, 1972 - 1976

Region	Total Marginal Production*		Probability of Closure		Annual Capacity Removed	
	Mills	Annual Capacity (000 tons)	Status Quo** (%)	Additional Abatement (%)	Status Quo** (000 tons)	Additional Abatement (000 tons)
New England	3	160	0	67	0	87
North Central	6	220	33	100	50	220
West	3	120	0	33	0	40
Totals	12	500	10	70	50	350

* i.e., Vulnerable to increased pollution abatement costs.

** Assumes no additional pollution abatement expenditures above current levels.

Source: Arthur D. Little, Inc. estimates.

Arthur D Little Inc

TABLE 9

SEMI-CHEMICAL PULP MILL SHUTDOWN PROBABILITIES, 1972 - 1976

Region	Total Marginal Production		Probability of Closure		Annual Capacity Removed	
	Mills	Annual Capacity (000 tons)	Status Quo* (%)	Additional Abatement (%)	Status Quo* (000 tons)	Additional Abatement (000 tons)
North Central	6	100	0	50	0	50
South Central	1	50	0	100	0	50
West	2	100	0	50	0	35
Totals	9	250	0	55	0	135
% of Total Industry	22	6			0	3.5

* Assumes no additional pollution abatement expenditures above current levels.

Source: Arthur D. Little, Inc. estimates.

Arthur D Little Inc

rigorous historical competition from secondary fiber. Clearly, in the absence of pollution abatement, semi-chemical pulp would continue to grow at 4–5% per year, and decreases in this rate of growth can be attributed to pollution abatement expenses.

In summary it seems that both sulfite and NSCC pulp would be able to sustain a status quo or growth condition in the absence of pollution abatement; with pollution abatement some diminution in each is anticipated with the impact felt rather more strongly in the future of sulfite than in the future of semi-chemical pulp producers.

2. Tissue Paper

Table 10 shows the number of tissue mills and average daily capacity which we consider to be marginal, along with the criteria for selecting these mills. It indicates that nearly half of the mills and 20% of the capacity are considered marginal by comparison with the larger, more modern mills in this product sector. Nearly all of this marginal capacity is located in the New England, Middle Atlantic and East North Central regions.

Table 11 shows the financial characteristics of marginal tissue mills in 1970 derived from a sampling of eight small mills with an average daily capacity of about 40 tons per day. These mills are integrated to converting but not to pulp, relying instead on purchased market pulp. Our analysis indicates that such mills actually operated at a loss in 1970, primarily because of weak prices in the tissue paper market coupled with relatively high market pulp prices. While we expect tissue product prices to increase in 1972 and 1973, due to tightening supply/demand balances, market pulp prices are expected to increase at an even greater rate. Therefore, the only significant profit improvement in this sector will come from the increased capacity utilization foreseen for the entire industry sector. While this may correct the current deficit situation for many marginal tissue mills, their return on investment is destined to remain very low. It is therefore unlikely that they will be able to obtain capital for pollution control equipment. If they are able to avoid capital costs by joining into a municipal water treatment system, it is still questionable whether they can pass on all of their increased operating costs which will amount to 3–5% of sales compared to about 2% of sales for a large-scale tissue producer.

As a result of the foregoing analysis Table 12 shows our estimates of tissue mill closures with and without additional pollution abatement expenditures over the next 5 years. This indicates that while about 15% of the marginal tonnage can be expected to shut down in any case, a full 50% is likely to be terminated in the face of increased pollution abatement costs. By far the major impact will be felt in the New England and Mid-Atlantic regions. The total production tonnage

TABLE 10

MARGINAL TISSUE MILLS

	No.	tpd
Total Mills	102	10,615
OK	53	8,730
Marginal	49*	1,885

*(Incl three fine paper mills)

MARGINAL CRITERIA:

1. Size -- under 50 tpd
2. Pulp Mill -- • pollution problem load
   • sulfite - no recovery
   • deinked
3. Product Value

Marginal Mills

Area	No. Mills	tpd
New England	19	730
Middle Atlantic	16	510
East North Central	7	385
West North Central	0	0
South Atlantic	2	90
East South Central	1	18
West South Central	0	0
West	4	150
Total	49	1885

Able-to-Cope Mills

Area	No. Mills	tpd
New England	7	670(1)
Middle Atlantic	15	2,265
East North Central	13	2,390(2)
West North Central	0	0
South Atlantic	2	500(3)
East South Central	3	1,100(4)
West South Central	1	100(5)
West	12	1,700
Total	53	8,725

(1) Incl. two mills which also produce fine papers.
(2) Incl. two mills which also produce fine papers; incl. one mill which also produces bleached wrapping paper.
(3) Mill also produces coarse papers.
(4) Incl. one mill which also produces bleached foodboard; one mill which also produces coarse and fine papers.
(5) Mill also produces coarse papers and foodboard.

Source: Arthur D. Little, Inc. estimates

TABLE 11

FINANCIAL CHARACTERISTICS OF MARGINAL TISSUE MILLS, 1970

	$000	% of Sales	% of Fixed Assets
Sales *	6,500	100	170
Profit (Loss) Before Tax	(500)	(7.7)	(13)
Profit (Loss) After Tax	(150)	(2.3)	(4)
Depreciation	300	4.6	8
Cash Flow	150	2.3	4
Net Fixed Assets	2,800	43	75
Total Fixed Assets	3,300	59	100

Operating Rate 80% of Capacity, averaging 40 tons/day.

Pollution Abatement Cost Range: 3 - 5% of Sales

* Reflects integrated converting and papermaking

Source: Arthur D. Little, Inc., sampling of representative mills

TABLE 12

TISSUE PAPER MILL SHUTDOWN PROBABILITIES, 1972 - 1976

Region	Total Marginal Production		Probability of Closure		Annual Capacity Removed	
	Mills	Annual Capacity (000 tons)	Status Quo* (%)	Additional Abatement (%)	Status Quo* (000 tons)	Additional Abatement (000 tons)
New England	18	250	20	60	50	150
Mid-Atlantic	16	180	20	60	35	110
North Central	7	130	0	30	0	40
South Atlantic	2	30	0	50	0	15
South Central	1	6	100	100	6	6
West	4	52	25	50	15	25
TOTAL (Rounded)	49	650	15	50	105	345
% of 1973 Capacity		14			2.6	8.0
% of 1976 Demand		14			2.5	7.7

* Assumes no additional pollution abatement expenditures above current levels.

Source: Arthur D. Little, Inc. estimates.

Arthur D Little Inc

involved is small and will be easily absorbed by the larger mills. However, a large number of small mills will be affected and these are often located in small towns with limited alternative employment opportunities. The employment impact is accentuated by the fact that a relatively labor-intensive converting operation is usually attached to the mill.

3. Printing, Writing and Related Papers

Table 13 shows the criteria, number and capacity of marginal printing and writing paper mills. It indicates that about 70% of the mills and nearly 50% of the industry capacity are marginal by today's standards of efficiency. Most of this marginal capacity is located in the New England, East North Central and Mid-Atlantic regions.

Table 14 indicates the 1970 financial performance of the typical marginal mill to which we refer. This analysis employs a composite performance of 17 non-integrated companies compiled by the American Paper Institute. It indicates that such mills were operating at an extremely low level of profitability in 1970. Based on the financial performance of the larger publicly-held companies in the first three quarters of 1971 there has been no improvement in the profitability of smaller firms this year. We do expect a rapid tightening of the supply/demand balance in this sector of the industry in 1972 and 1973 which should significantly improve labor productivity and cause prices to rise. However, the nonintegrated mills will be faced with steeply rising pulp prices; thus their profitability will not improve nearly as much as companies integrated to pulp. The main pollution-related difficulties encountered by marginal mills will be either in obtaining the necessary capital (because of their low profitability) or in justifying its expenditure in a relatively obsolete mill. Many of these mills are parts of larger companies, which in many cases will elect to centralize their production in a larger mill rather than revamp a marginal mill. It is unlikely that the increased operating costs for pollution abatement will eliminate the profits of these mills. These costs, as a percent of their sales, are small; while their cost per ton is considerably higher than those of the larger firms the impact as a percent of sales is mitigated by the fact that the smaller mills tend to make higher valued products.

Table 15 shows our estimates of the amount of marginal tonnage likely to be shut down over the next five years, with and without additional pollution abatement costs. It indicates that 10% of the marginal tonnage will probably be removed in any case and that an additional 10% will close mainly because of the inability to cope with the additional pollutional abatement costs. The affected closures will be spread over four regions in descending order of importance: New England, Mid-Atlantic, North Central and West Coast. The total tonnage involved is greater than the slack capacity anticipated in 1973. However, we

TABLE 13

MARGINAL PRINTING, WRITING AND RELATED PAPER MILLS
(Except News and Uncoated Groundwood)

	No.	tpd
Total Mills	138	29,175
OK	41	15,650
Marginal	97	13,525

MARGINAL CRITERIA:

1. Size -- under 200 tpd
2. Pulp Mill --
   - non-integrated
   - rag or deinked
   - sulfite or NSSC
   - hi-pollution load

Marginal Mills

Area	No. Mills	tpd
New England	32	5,400
Middle Atlantic	21	2,975
East North Central	31	3,600
West North Central	2	335
South Atlantic	4	155
East South Central	0	0
West South Central	1	125
West (2 subdivisions)	6	930
Total	97	13,525

Able-to-Cope Mills

Area	No. Mills	tpd
New England	4	1,665
Middle Atlantic	5	1,875
East North Central	17	6,295
West North Central	0	0
South Atlantic	5	2,335
East South Central	4	1,375
West South Central	3	1,300
West (2 subdivisions)	3	790
Total	41	15,650

Source: Arthur D. Little, Inc. estimates

TABLE 14

FINANCIAL CHARACTERISTICS OF MARGINAL PRINTING & WRITING PAPER MILLS, 1970

	$000	% of Sales	% of Total Assets
Sales	13,000	100.0	114.0
Profit Before Tax	195	1.5	1.8
Profit After Tax	115	0.9	1.1
Depreciation	575	4.4	5.0
Cash Flow	690	5.3	6.1
Net Assets	6,200	48.0	55.0
Total Assets	11,500	87.0	100.0

Operating Rate 85% of Capacity, averaging 150 tons/day.

Pollution Abatement Cost Range: 3.5 - 6.0 % of Sales

Source: American Paper Institute composite of non-integrated companies.

TABLE 15

PRINTING AND WRITING PAPER MILL SHUTDOWN PROBABILITIES, 1972 - 1976

Region	Total Marginal Production		Probability of Closure		Annual Capacity Removed	
	Mills	Annual Capacity (000 tons)	Status Quo* (%)	Additional Abatement (%)	Status Quo* (000 tons)	Additional Abatement (000 tons)
New England	32	1,900	10	20	190	380
Mid-Atlantic	21	1,040	10	20	100	200
North Central	33	1,370	10	15	140	210
South Atlantic	4	55	0	0	0	0
South Central	1	45	0	0	0	0
West	6	320	20	30	60	100
TOTAL (Rounded)	97	4,730	10	20	490	890
% of 1973 Capacity		45			4.7	8.5
% of 1976 Demand		43			4.4	8.0

* Assumes no additional pollution abatement expenditures above current levels.

Source: Arthur D. Little, Inc. estimates.

Arthur D Little Inc

expect that shifts in capacity to other larger mill locations will more than make up for the capacity lost by 1976.

4. Special Industrial Paper

Table 16 shows the number of marginal mills, their capacity and the criteria for selection in the special industrial paper sector. It documents our estimate that 25% of the mills and 16% of the capacity are marginal by current standards. About half of this tonnage is in the Mid-Atlantic region and the remainder distributed equally between the New England, East North Central and South Atlantic regions.

Table 17 illustrates the 1970 financial characteristics of a typical marginal mill based on a composite of five mills. Since these mills are parts of larger companies, we employed the capitalization measure of total fixed assets which approximates total assets. The 4% return on gross fixed assets achieved by these mills in 1970 is certainly less than an adequate return from an investment standpoint, although it is comparable to the industry average in that year. This sector has benefited from weak pulp prices in 1971; however, this was offset by generally weak industrial paper prices caused by continued significant overcapacity. Thus, profits have not improved significantly, if at all. We anticipate that this sector will continue to experience a cost/price squeeze through 1973 as market pulp prices increase at a faster rate than those of special industrial paper. This is one of the few industry sectors where we anticipate continued slack capacity through 1973. Under these conditions, the additional cost of pollution abatement could well eliminate the profit margins of the marginal firms. The wide range in abatement costs, from 2.5% to 6% of sales, is caused primarily by the wide range in product values as well as mill production volumes. Thus, a small mill producing a relatively low-valued industrial paper product mix is particularly vulnerable. This profitability factor is accentuated by the fact that the anticipated abatement costs for the typical large mill in this sector are only about 1.5% of sales.

Table 18 shows our estimates of the amount of capacity likely to be closed by 1976 with and without additional pollution abatement costs. It indicates that about 30% of the marginal capacity is likely to be removed in any case while as much as 85% of this capacity is likely to be shut down when faced with additional pollution abatement costs. The tonnage involved, however, is small and can certainly be made up by the larger firms in this industry. The impact caused by additional pollution abatement costs will be felt mainly in the Mid-Atlantic region and to a lesser extent in the South Atlantic and New England areas.

TABLE 16

MARGINAL SPECIAL INDUSTRIAL PAPER MILLS

	No.	tpd
Total Mills	36	1120
OK	27	935
Marginal	9	185

MARGINAL CRITERIA:

1. Size -- 25 tpd and under
2. Non-integrated with other products
3. Grade value

Marginal Mills

Area	No. Mills	tpd
New England	2	35
Middle Atlantic	5	90
East North Central	1	25
West North Central	0	0
South Atlantic	1	35
East South Central	0	0
West South Central	0	0
West	0	0
Total	9	185

Able-to-Cope Mills

Area	No. Mills	tpd
New England	10	460
Middle Atlantic	8	175
East North Central	6	230
West North Central	0	0
South Atlantic	1	20
East South Central	2	50
West South Central	0	0
West	0	0
Total	27	935

Source: Arthur D. Little, Inc. estimates

TABLE 17

FINANCIAL CHARACTERISTICS OF MARGINAL SPECIAL INDUSTRIAL PAPER MILLS, 1970

	$(000)	% of Sales	% of Fixed Assets
Sales	5,000	100	167
Profit before tax	240	4.8	8.0
Profit after tax	120	2.4	4.0
Depreciation	100	2.0	3.3
Cash Flow	220	4.4	7.3
Net fixed assets	1600	32	53
Total fixed assets	3,000	60	100

Operating rate about 75% of capacity, averaging 20 tons/day.

Poliution Abatement Cost Range: 2.5 - 6% of sales

Source: Arthur D. Little, Inc. sampling of representative mills.

TABLE 18

SPECIAL INDUSTRIAL PAPER MILL SHUTDOWN PROBABILITIES 1972 - 1976

Region	Total Marginal Production		Probability of Closure		Annual Capacity Removed	
	Mills	Annual Capacity (000 tons)	Status Quo* (%)	Additional Abatement (%)	Status Quo* (000 tons)	Additional Abatement (000 tons)
New England	2	10	50	100	5	10
Mid-Atlantic	5	30	20	60	6	20
North Central	1	10	100	100	10	10
South Atlantic	1	10	0	100	0	10
TOTAL (Rounded)	9	60	30	85	20	50
% of 1973 Capacity		10			3.4	8.6
% of 1976 Production		12			3.8	9.6

* Assumes no additional pollution abatement expenditures above current levels.

Source: Arthur D. Little, Inc. estimates.

Arthur D Little Inc

5. Combination Paperboard

Table 19 shows our estimates of the number and tonnage of combination paperboard mills and the criteria used in their selection. It indicates that nearly 50% of the mills and 25% of the total sector capacity falls into the marginal category. This sector has been the hardest hit in the paper industry from the standpoint of mill shutdowns with nearly one million tons of annual capacity removed in 1970 and 1971. Nevertheless, a significant amount of overcapacity still exists in this sector and many mills similar to those that were shut down in the past 18 months continue to operate. The Mid-Atlantic region is the most vulnerable to the impact of further shutdowns followed by the East North Central and New England regions. Potential mill dislocations in other parts of the country are relatively minor by comparison.

Table 20 illustrates the financial characteristics of a typical marginal combination board mill in 1970. This analysis was based on a sampling of four mills that were actually closed in 1971, but that are representative of a number of mills still in operation. We have estimated that the operating rate in this sector will improve to about 94% of capacity in 1973, compared to 86% in 1970; thus, market conditions will be conducive to increased prices and profit margins. However, we have greater uncertainty about this forecast than in any other paper industry sector. It is predicated upon an estimated average annual growth in demand of 3% per year over the next five years on the basis of growing use of recycled paper products; this contrasts with no growth in this product sector during the 1960's. At the moment we are unsure how rapidly this increased demand will materialize. On the other hand, a sharply increased demand for recycled paper products will cause waste paper prices to increase significantly, particularly in view of the labor-intensiveness of the collection process which is extremely difficult to mechanize. Therefore, the marginal mills are still likely to face a cost/price squeeze unless they are able to upgrade their product mix to higher valued products. Also, their pollution abatement costs as a percent of sales are somewhat higher than those of larger mills, mainly because of their smaller size.

Table 21 shows our estimates of the combination paperboard capacity likely to be removed by 1976, with and without additional pollution abatement costs. It indicates a 10% removal of marginal capacity with no additional pollution abatement cost compared with a 25% removal when the factor of additional abatement cost is considered. The Mid-Atlantic region will feel the greatest impact followed by the New England and North Central areas. Minor effects will be felt in the South Atlantic and Western regions. The total tonnage affected, however, is small in comparison with total sector capacity and can certainly be made up by capacity expansions at the larger, more viable mills.

TABLE 19

MARGINAL COMBINATION PAPERBOARD - WET MACHINE BOARD MILLS

	No.	tpd
Total Mills	170	24,525
OK	91	18,355
Marginal	78	6,170

MARGINAL CRITERIA:

Combination Paperboard: Folding Boxboard, Non-folding, Set-up
1. Size -- 100 tpd, no. of machines, size and age
2. Integration to converting
3. Product value
4. Pollution -- receiving waters
5. Raw material availability
6. Markets and management

Jute, bogus medium and linerboard
1. Size -- 100 tpd, no. of machines, trim and age
2. Integration to converting
3. Company characteristics
4. Markets, management
5. Pollution - receiving waters
6. Raw material availability

Marginal Mills

Area	No. Mills	tpd
New England	19	1,280
Middle Atlantic	29	2,575
East North Central	19	1,470
West North Central	1	35
South Atlantic	6	510
East South Central	1	115
West South Central	0	0
West	3	185
Total	78	6,170

Able-to-Cope Mills

New England	13	1,230
Middle Atlantic	17	4,675
East North Central	31	7,100
West North Central	4(1)	320
South Atlantic	6(1)	1,235
East South Central	5	740
West South Central	2	410
West	13	2,140
Total	91	18,355

Note:
(1) Mill produces NSCC medium (not bogus), but is likely to switch.

Source: Arthur D. Little, Inc. estimates

TABLE 20

FINANCIAL CHARACTERISTICS OF MARGINAL COMBINATION BOARD MILLS, 1970

	$(000)	% of Sales	% of Fixed Assets
Sales	3,000	100	66.6
Profit before tax	90	3	2.0
Profit after tax	45	1.5	1.0
Depreciation	100	3.3	2.2
Cash flow	145	4.8	3.2
Net fixed assets	1,200	40	27
Total fixed assets	4,500	150	100

Operating rate 80% of capacity, averaging 80 tons/day.

Pollution Abatement Cost Range: 5 - 8% of Sales

Source: Arthur D. Little, Inc. sampling of representative mills.

TABLE 21

COMBINATION PAPERBOARD MILL SHUTDOWN PROBABILITIES, 1972 - 1976

Region	Total Marginal Production		Probability of Closure		Annual Capacity Removed	
	Mills	Annual Capacity (000 tons)	Status Quo* (%)	Additional Abatement (%)	Status Quo* (000 tons)	Additional Abatement (000 tons)
New England	19	425	15	30	60	130
Mid-Atlantic	29	850	10	30	90	250
North Central	20	485	10	25	50	120
South Atlantic	6	170	0	10	0	20
South Central	1	40	0	0	0	0
West	3	60	0	33	0	20
TOTAL (Rounded)	78	2,030	10	25	200	540
% of 1973 Capacity		25			2.5	6.6
% of 1976 Demand		25			2.5	6.6

* Assumes no additional pollution abatement expenditures above current levels.

Source: Arthur D. Little, Inc. estimates.

Arthur D Little Inc

6. Other Product Sectors

Table 22 summarizes our estimates of the likely capacity removal by 1976 in other sectors of the paper industry with and without additional pollution abatement costs. The product sectors included here in descending order of the amount of dislocations we expect are: insulating board, newsprint and uncoated groundwood papers, packaging paper and board (except that made from waste paper), construction paper and hardboard. Each of these sectors will be less affected by pollution abatement costs than the sectors discussed previously in this chapter. The greatest dislocations in these product sectors are expected to occur in the New England, North Central, Western and South Central regions. However, the total tonnage involved is very small in relation to the total capacity and demand for these grades. Thus, there will certainly be a sufficient capacity available in the remaining mills to make up for the loss. To back up the analysis shown in Table 22 we estimated the probability of closure in each of the individual product sectors.

Table 23 shows our analysis and criteria for marginal mills in the insulation board sector. Here only six mills are involved. We believe that these will be closed by 1976 regardless of whether they are faced with additional pollution abatement costs mainly because we expect no growth in demand and continuing overcapacity through 1976. Thus, all of the marginal mills are likely to be closed strictly because of economic considerations.

Table 24 shows a similar analysis for newsprint and uncoated groundwood paper mills. All of this marginal tonnage is located in the New England, Western and North Central regions. We estimate that by 1976, in the face of increased pollution abatement costs, two mills will close in New England, one in the North Central region, and one in the West. Without additional pollution abatement costs, probably only one New England mill would close.

Our analysis of marginal packaging paper and board mills (excluding combination board) is shown in Table 25. About 60% of this tonnage is located in the North Central region. We expect significantly improved operating rates for most of these products in 1972 and 1973. Thus, in view of the associated price increases expected, it is unlikely that any of these mills would close by 1976, if they did not have to incur additional pollution abatement costs. We estimate that the anticipated abatement costs will cause one mill to close in each of the following regions: New England, North Central, South Central, and West.

A different set of reasons support our conclusion that few, if any, semi-chemical corrugating medium mills will close as a result of additional pollution control requirements. Our supply/demand analysis indicates that this sector should continue to experience significant overcapacity through 1973; this implies

TABLE 22

OTHER PAPER AND BOARD MILL SHUTDOWN PROBABILITIES, 1972 - 1976

Region	Total Marginal Production		Probability of Closure		Annual Capacity Removed	
	Mills	Annual Capacity (000 tons)	Status Quo* (%)	Additional Abatement (%)	Status Quo* (000 tons)	Additional Abatement (000 tons)
New England	11	665	15	45	100	290
Mid-Atlantic	6	165	10	10	15	15
North Central	26	1,400	5	15	50	210
South Atlantic	3	75	0	0	0	0
South Central	15	430	10	25	40	100
West	14	580	0	30	0	160
TOTAL (Rounded)	75	3,315	5	25	200	780
% of 1973 Capacity		8.4			0.5	2.0
% of 1976 Production		7.9			0.5	1.9

* Assumes no additional pollution abatement expenditures above current levels.

Source: Arthur D. Little, Inc. estimates.

Arthur D Little Inc

TABLE 23

MARGINAL INSULATION BOARD MILLS

	No.	tpd
Total Mills	23	5,600
OK	17	5,205
Marginal	6	395

MARGINAL CRITERIA:

1. Size -- under 100 tpd
2. Location - re. pollution

Marginal Mills

Area	No.	tpd
New England	1	80
Middle Atlantic	1	45
East North Central	0	0
West North Central	2	150
South Atlantic	0	0
East South Central	0	0
West South Central	2	120
West	0	0
Total	6	395

Area	No.	tpd
New England	1	100
Middle Atlantic	2	155
East North Central	3	550
West North Central	2	1,300
South Atlantic	1	400
East South Central	4	1,500
West South Central	2	925
West	2	275
Total	17	5,205

Source: Arthur D. Little, Inc. estimates

TABLE 24

MARGINAL NEWSPRINT AND UNCOATED GROUNDWOOD PAPER MILLS

	No.	tpd
Total Mills	32	14,785
OK	21	11,940
Marginal	11	2,845

MARGINAL CRITERIA:

1. Size -- under 350 tpd
2. Pulp Mill -- • deinking
   • non-integrated to chem pulp
   • sulfite without recovery

Marginal Mills

Area	No. Mills	tpd
New England	5	1,225
Middle Atlantic	0	0
East North Central	2	550
West North Central	1	200
South (3 subdivisions)	0	0
West (2 subdivisions)	3	870
Total	11	2,845

Able-to-Cope Mills

Area	No. Mills	tpd
New England	2	1,980
Middle Atlantic	2	900
East North Central	1	250
West North Central	1	250
South Atlantic	2	860
East South Central	3(1)	2,900
West South Central	3(2)	2,100
West	7(3)	2,700
Total	21	11,940

(1) Incl. one mill which also produces variety bleached and unbleached kraft papers.
(2) Incl. one mill which also produces linerboard.
(3) Incl. two mills which produce kraft containerboard; one mill which produces tissue.

Source: Arthur D. Little, Inc. estimates

TABLE 25

MARGINAL PACKAGING PAPER AND BOARD MILLS

	No.	tpd
Total Mills	97	74,160
OK	80	70,425
Marginal	17	3,735

MARGINAL CRITERIA:

1. Size -- under

tpd	
200	- unbleached kraft paper
400	- unbleached kraft board
400	- bleached kraft board
200	- semi-chemical medium

2. No recovery - NSSC
3. Unusual pollution load

Marginal Mills

Area	No. Mills	tpd
New England	2	540
Middle Atlantic	0	0
East North Central	7	1,605
West North Central	2	550
South Atlantic	0	0
East South Central	1	150
West South Central	3	540
West	2	350
Total	17	3,735

Able-to-Cope Mills

Area	No. Mills	tpd
New England	0	0
Middle Atlantic	0	0
East North Central	5	2,220
West North Central	0	0
South Atlantic	31	30,670
East South Central	15	10,855
West South Central	15	15,430
West	14	11,250
Total	80	70,425

Note: NSSC mills with cross recovery and integrated with large board mills not shown separately -- includes the following NSSC mills:

South Atlantic	7
West South Central	4
West	5
	16

Source: Arthur D. Little, Inc. estimates

that profitability will continue to be insufficient to justify capital expenditures on non-productive pollution abatement equipment. However, after discussing this situation with a number of contacts close to this industry sector, we believe that when faced with this situation the management of many such mills will elect to close their semi-chemical pulp mills which cause most of their pollution problem, and switch to the use of waste paper as their fiber raw material. So doing will also help them meet the new Government requirements concerning amounts of post-consumer waste paper to be used in corrugated shipping containers. It is easier for most paperboard producers to meet this requirement by utilizing waste paper in the corrugating medium rather than adding waste paper to the linerboard component of the container. Since the employment involved in the re-pulping of waste paper is fairly close to that required in a semi-chemical pulp mill, this change in raw material sources will have relatively little effect on employment in this sector. It will, however, have an effect on the logging firms that supply these mills; this impact is discussed in Chapter IV.

Table 26 shows our analysis of marginal mills in the construction paper sector. We have denoted a large number of marginal mills in this sector mainly because of the prevalence of many small mills located near urban centers. This sector as a whole had extremely low or non-existent profits in 1970. However, with the significant growth in new residential construction, coupled with a large amount of remodeling activity in 1971, this sector is operating at full capacity, and is now one of the more profitable portions of the paper industry. We estimate that residential housing construction activity will continue to remain relatively strong through 1976. Therefore we believe that most building paper mills will be able to cope with the additional pollution control requirements. This reasoning was reinforced by conversations with the management of several firms in this sector and led us to the conclusion that none of these mills will be shut down as a result of the additional abatement costs anticipated through 1976.

We came to the same conclusion in the case of the marginal hardboard mills which are analyzed in Table 27. In this sector we expect a growth rate averaging 5.5% per year through 1976, and a continuing tight supply/demand at least through 1973. Thus, the marginal producers should be able to survive under the umbrella of price increases in spite of the additional costs anticipated for pollution abatement through 1976.

C. EMPLOYMENT

In Table 28 we have reported the anticipated jobs lost in the various regions of the country and in the various product categories based on expected mill closures resulting from the anticipated pollution abatement requirements through 1976.

TABLE 26

MARGINAL CONSTRUCTION PAPER MILLS

(Incl. Roofing Felt)

	No.	tpd
Total Mills	47	5,535
OK	16	3,465
Marginal	31	2,070

MARGINAL CRITERIA:

1. Size -- under 100 tpd
2. Location - re. pollution

Marginal Mills

Area	No.	tpd
New England	2	50
Middle Atlantic	5	440
East North Central	7	660
West North Central	3	210
South Atlantic	2	130
East South Central	3	170
West South Central	6	290
West	3	120
Total	31	2,070

Able-to-Cope Mills

Area	No.	tpd
New England	0	0
Middle Atlantic	5	1,740
East North Central	4	820
West North Central	1	150
South Atlantic	2	225
East South Central	1	110
West South Central	3	420
West	0	0
Total	16	3,465

Source: Arthur D. Little, Inc. estimates

TABLE 27

MARGINAL HARDBOARD MILLS

	No.	tpd
Total Mills	29	5,845
OK	19	5,270
Marginal	10	575

MARGINAL CRITERIA:

1. Size -- 100 tpd
2. Location - re. pollution

Marginal Mills

Area	No.	tpd
New England	1	10
Middle Atlantic	0	0
East North Central	1	50
West North Central	1	75
South Atlantic	1	90
East South Central	0	0
West South Central	0	0
West	6	350
Total	10	575

Able-to-Cope Mills

Area	No.	tpd
New England	0	0
Middle Atlantic	2	520
East North Central	1	430
West North Central	1	240
South Atlantic	3	790
East South Central	3	1,600
West South Central	3	740
West	6	950
Total	19	5,270

Source: Arthur D. Little, Inc. estimates

TABLE 28

ANTICIPATED PAPER INDUSTRY JOBS LOST BY 1976 DUE TO ADDITIONAL POLLUTION ABATEMENT REQUIREMENTS

PRODUCT SECTOR	New England	Middle Atlantic	North Central	South Atlantic	South Central	West	Totals (Rounded)
Sulfite and NSSC	130	---	300	---	70	110	610
Tissue	2800	2100	1100	420	--	280	6700
Printing and Writing Paper	1770	950	650	---	--	380	3750
Special Industrial Paper	100	300	---	200	--	--	600
Combination Paperboard	450	1050	450	130	--	130	2210
Other Products	750	---	650	--	240	650	2290
TOTAL (Rounded)	6000	4400	3150	750	310	1550	16,160

Source: Arthur D. Little, Inc., estimates

Arthur D Little Inc

The principal product areas in which closures are expected to occur include sulfite and semi-chemical pulp, tissue, printing and writing paper, special industrial paper, combination paperboard, newsprint and packaging paper.

Our analysis foresees the loss of 6000 jobs in New England, 4400 in the Middle Atlantic region and 3150 in the North Central region. These three regions will incur about 85% of the paper industry unemployment foreseen as a result of pollution abatement requirements through 1976. The remaining 15% of the jobs lost will be split about equally between the West and the South.

Within some of these regions the loss of employment will be relatively localized. Principal examples are small communities in western and central Massachusetts and Connecticut and the northern portions of New York and Wisconsin. Most of these communities are in areas already considered "depressed" by the Economic Development Administration, which indicates that there are relatively few nearby employment alternatives for the workers affected. It should be noted that the production capacity lost from marginal mill closures will be made up by mill construction or expansion principally in the South and West, and to a lesser extent in Maine and Minnesota. While such expansions will more than compensate for pollution related jobs lost in the South and the West, they will do little to relieve the unemployment in the other regions. These capacity expansions not only will involve long distance moves by the unemployed mill workers, but also will offer fewer jobs due to economies of scale.

In addition to the direct employment losses there will be indirect losses of jobs in local service and supplier industries. These generally amount to about 200% of the direct labor impact and will raise the unemployment totals accordingly. The impact of these employment losses will be substantial in a number of smaller cities and towns, particularly in New England, New York, Pennsylvania, Indiana, Ohio, Michigan and Wisconsin. Many rural communities in these areas are dependent in large measure on the local paper industry.

D. INTERNATIONAL COMPETITIVENESS

World production of pulp and paper products focusses upon three major areas: the United States, Canada and Scandinavia. Pulp and paper is one of relatively few product areas where the United States continues to maintain a generally favorable position relative to foreign competition. We have been able to do so mainly because of the economies of scale realized in our extremely large mills, coupled with our abundant timber resources and the resulting low procurement cost of pulpwood delivered to the mill sites. Pulpwood costs in Scandinavia are significantly higher because the demand now exceeds their timber growth rate. In eastern Canada production centers heavily on newsprint, a significant quantity of which is produced in relatively obsolete mills. In addition, eastern

pulpwood costs tend to be higher than those in the southern and western United States because of the difficulties of harvesting and transporting the wood in Canada. Western Canada supports large, integrated lumber, pulp and paper complexes with relatively low wood costs typical of the U.S. Pacific Northwest.

More importantly from the standpoint of this analysis, there is very little difference in the objectives and timetables for reducing paper industry air and water pollution in all these regions. We expect that the United States will be the leader in the provision of systems for purification of air- and water-borne emissions. This will result in some short-term timing differences associated with the rate of adoption of pollution control systems, causing some differences in capitalization and costs which will be unfavorable to U.S. producers. However, we expect that the timing difference in implementation between these regions will be very short (perhaps three years). Consequently, the U.S. producers will not be placed at such a disadvantage as to cause substantial shifts in World trade patterns and capital flow for pulp and paper production. We do expect increased net imports of newsprint and a decline in the rate of growth of linerboard exports over the next several years; however, this will result mainly from the expected tightening of supply/demand balances in the United States as our economic growth is restored rather than from any significant decline in the competitiveness of U.S. producers.

IV. INDIRECT ECONOMIC IMPACT

A. EFFECT ON SUPPLIER INDUSTRIES

1. Logging Industry

The direct employment entailed in felling, bucking, loading and hauling pulpwood to a mill (including direct supervision and equipment maintenance) totals about one man-year per 700 cords of pulpwood delivered. All indirect employment is believed to be about 1/2 man-year per 700 cords of pulpwood delivered. The impact of reduced pulpwood consumption is thus expected to be as follows:

Region	Reduction in Pulpwood Harvest	Direct Job Reduction	Indirect Job Reduction
New England	150,000 cords	210	105
North Central	500,000	720	360
South Central	50,000	70	35
West	260,000	370	185

In the New England and North Central regions the reduction in pulpwood demand will have a more significant impact than the above numbers indicate. Most of the reduction will be in hardwood species; this timber is predominantly owned and supplied by small woodlot owners. Many harvest their wood on a part-time basis to obtain supplementary income, particularly when alternative job opportunities such as farming and construction work are not available. Thus many part-time jobs are at stake; pulpwood payments for many families, while not the principal source of income, make the difference between having or not having discretionary income. Most of the hardwood timber in these areas is of small size and low quality, unsuitable for anything other than fiber products: pulp and paper and composition board. Demand for roundwood in composition board is insignificant now and, given the abundance of sawmill and planning mill residue, is expected to remain insignificant for at least 10 years. Thus, for these areas pulp is the only alternative in this decade for this resource.

In the South the job loss is small and will be offset by growing demand for softwood pulpwood and sawlog production. In the West where the reduction of pulpwood demand reflects a decline in softwood consumption the potential decline in jobs will probably be offset by increased export of wood chips. This is particularly likely since the woods labor here is primarily involved in sawlog

production and the pulp mill purchases mostly sawmill residue not roundwood. For the sawmills to keep in operation they will have to find new outlets for their residue but we expect them to be able to do so.

2. Salt Cake

In the kraft pulping system sodium sulfide and sodium hydroxide are the active pulping chemicals. Sodium and sulfur values are lost from the kraft pulping and associated recovery system in a variety of ways. Because of the volatility of organic and a few inorganic sulfur compounds, a higher percentage of the sulfur is lost than of sodium. Salt cake provides sodium and sulfur in approximately the same ratio as they are lost and so is widely used as a source of make-up chemicals for the kraft pulping system. About 70% of the total salt cake consumed in the United States goes into kraft pulping.

Pressure to reduce air pollution in the kraft industry has resulted in a decrease in the consumption of salt cake. Over the past 20 years, consumption per ton of pulp has decreased from over 200 pounds to 110-130 pounds. It is expected that this trend will continue and consumption will be in the neighborhood of 75 pounds per ton of pulp in 1976. Despite a projected increase in kraft pulp production, the potential total U.S. demand for salt cake in kraft pulping is expected to decrease by about 20% in the 1971-76 period.

The market for salt cake in kraft pulping is being reduced further by the use of other sources of sodium-sulfur values as make-up chemical. Caustic wash solutions from oil refineries contain sulfides and other sulfur compounds. These refinery wastes are being used in the place of salt cake as make-up chemicals in kraft pulping systems. An important source of sodium-sulfur values for kraft pulping is the spent liquor from NSSC pulping. When the NSSC mill is located at the same site as the kraft mill the spent pulping liquor can be combined with a kraft liquor and will supply the needed sodium and sulfur values as make-up for the kraft cooking liquor. A third major source of sodium sulfur values for kraft mills is the by-product salt cake from captive chlorine dioxide manufacturing facilities. The net result of the availability of these other sources of sodium-sulfur values in competition with salt cake, plus the expected decrease in the consumption of salt cake per ton of pulp, will be close to a 60% decrease in the consumption of purchased salt cake by the kraft industry in 1976 (compared to 1970). The estimated consumption of purchased salt cake by the U.S. kraft industry in 1976 will be 900,000 tons vs 2,000,000 tons in 1970. It would be 2,000,000 tons in 1976 if the level of salt cake consumption per ton of pulp did not change in the 1970-76 period.

By 1976, the only U.S. markets of any magnitude for purchased salt cake in kraft pulping will be in the southeastern United States (about 650,000 tons

per year) and the northwestern United States (total of 250,000 tons for both the United States and Canada in northwestern North America). At the present time the southeastern U.S. requirements are met by imported salt cake, by-product salt cake from rayon and cellophane manufacture, Mannheim furnaces, bichromate manufacture, and naturally occurring salt cake, from Texas and the West Coast.

By 1976 the requirements can be met almost entirely by the by-product salt cake. Most of this is generated in the eastern and the southeastern area of the United States, so it is favored by the lower transportation charges, in comparison with imported and West Coast salt cake. If the level of salt consumption per ton of pulp remained unchanged in southeastern United States, 1970-76 estimated purchase salt cake requirements would be about 1,400,000 tons. Thus the estimated actual consumption of 650,000 tons would lead to a loss of 750,000 tons – mostly from imported and natural salt cake. Estimated loss of employment is 350 jobs, primarily from domestic natural salt cake production.

In northwestern North America the present requirements are met largely by western U.S. and Saskatchewan natural salt cake deposits. There will be a decrease of about 200,000 tons in the demand for purchased salt cake in the 1970-76 period, and of course the 1976 demand will be met by the naturally occurring chemical. With no change in the level of salt cake consumption per ton of pulp, 1976 demand for purchased salt cake would be 450,000 tons. The loss of employment attributable to the difference between 450,000 and 200,000 tons is equivalent to 140 jobs.

With regard to the remaining areas of the United States – in New England the demand for purchased salt cake will decline by about 30,000 tons per year in the 1970-76 period. At present the demand is met by imported and by-product salt cake. In the Great Lakes area, including both U.S. and Canadian mills, the decline in purchased salt cake will amount to about 90,000 tons in the 1970-76 period. The demand is met by naturally occurring salt cake from Saskatchewan and by-product salt cake. The decreased demand will hit the imported and natural (Canadian) salt cake most heavily. Impact on U.S. employment will be slight.

3. Chlorine

An important source of water pollution from kraft mills is the bleach plant effluent. Dissolved organics and spent inorganic bleaching chemicals are present in low dilution in these mill effluents.

The major portion of the organic load and the offensive inorganic chemicals are in the mill effluent from the first two stages of the bleach plant – the

chlorination and caustic extraction stages. Substitution of these two stages by an alkaline oxygen stage has been developed and put into commercial operation in one mill (in South Africa) and has undergone large-scale pilot plant evaluation in another mill (the Hurum mill of Mo och Domsjo in Sweden). Another commercial mill, and the first one in the United States, is being installed at the Chesapeake Corporation mill in West Point, Virginia.

The effluent from the alkaline oxygen stage can be recycled back into the pulp mill and used as make-up process water in various stages of the recovery process. In this manner, a major portion of the dissolved organic material eventually goes to the recovery boiler and is burned. Thus, the bleach plant effluent leaving the mill is relieved of the major portion of the dissolved organic load and in addition there are no chlorinated organics or other reaction products of the chlorine to contribute to the water pollution problems. Our estimates of the process economics of oxygen bleaching indicate that the capital investment will be slightly higher than for conventional bleaching but that operating costs will be somewhat lower.

The technology appears to be sound and well established. We expect that a substantial portion of new kraft pulp mill bleach plants installed in the United States in the next five years will employ oxygen bleaching. In addition, bleached kraft pulp mills which are currently experiencing difficulties in meeting water pollution standards may switch from conventional chlorine-caustic extraction bleaching to alkaline-oxygen bleaching.

The kraft industry is one of the larger consumers of chlorine in the United States. In 1970, for example, 880,000 tons of chlorine were consumed in the manufacture of bleached kraft pulp. It is possible that 10% of the chlorine consumed in bleaching kraft pulp could be lost to oxygen bleaching by 1976. Projected consumption of chlorine in kraft pulping with an oxygen bleaching in 1976 is about 1,400,000 tons. Thus, oxygen bleaching could bring about a reduction of 140,000 tons in chlorine consumption. This reduction would result in a loss of roughly 70 jobs by 1976.

4. Effect on the Capital Good Industries

It is our conclusion that dislocational effects resulting from the application of water and air pollution abatement in the pulp and paper industry in the United States will not be of sufficient magnitude to cause measurable changes in market demand in any of the product sectors comprising the industry.

With respect to supply to meet market demand, we anticipate regional dislocations and the closure of antiquated facilities as discussed in other sections of this report, but we are convinced that the effects will be dislocational only and

will not create a temporary lull in the growth of the industry. We therefore foresee no depressing effects upon the magnitude of the business enjoyed by the capital goods suppliers dealing with pulp and paper industry.

On the other hand, the application of water and air pollution abatement by the industry will in itself create new increments of market demand for capital goods associated with the abatement processes. These effects will be substantial in the initial years as existing manufacturing plants expend capital with equipment suppliers, and construction contracts, in implementing pollution abatement plans to meet evolving criteria. We expect the total capital to be expended in the paper industry 1972-1976 will amount to $1.2 billion for water pollution and $800 million for air pollution or a total of $2 billion.

In addition, as the industry continues to grow (this growth rate is anticipated to average 4% per year), continuing investments in pollution abatement will be common. We anticipate that these continuing incremental investments in pollution abatement will approximate 3 to 5% of the total annual industry investment or $30–40 million per year.

B. EFFECT ON CUSTOMERS

Our analysis shows no measurable impact upon market demand trends which may be assignable to the burden of increased pollution abatement expenditures. Accordingly, we do not foresee significant changes in growth rates associated with the use of the various paper and board products comprising this industry. In every case where we anticipate capacity removals as a result of additional pollution abatement costs the larger, more efficient producers should be able to make up for the tonnage loss. Therefore, customers generally should have no difficulty in obtaining pulp and paper products as a result of this capacity removal.

However, we have noted earlier in Table 6 that price increases ranging from 2% to 10% of product value can be expected as a result of the additional pollution abatement costs anticipated through 1976. It should also be noted that in view of the current extremely low profitability of the pulp and paper industry, price increases are needed to restore profits to a level that will attract sufficient capital for capacity expansion to assure a continued supply of these products beyond 1973 when supply and demand is expected to be closely balanced. Thus, if the market behaves freely, customers of the pulp and paper industry can expect much more significant price increases caused by market and general economic factors than those due to pollution abatement costs. If stringent price controls are levied there is likely to be significant shortages of pulp and paper products after 1973.

C. EFFECT ON BALANCE OF PAYMENTS

In Section III-D of this report we presented the factors which led to our conclusion that the pollution abatement costs anticipated through 1976 will not significantly affect the international competitiveness of U.S. pulp and paper producers. The pollution abatement objectives are similar in all of the major pulp and paper producing regions of the world. Also differences in implementation timetables are expected to be small (probably less than three years). Therefore, these timing differences will not be sufficient to cause substantial shifts in world trade patterns and capital flow for pulp and paper production. Consequently, we conclude that pollution abatement in the pulp and paper industry will not exert a measurable impact upon United States' balance of payments with respect to Canada, Scandinavia, Western Europe or other competing regions of the World.

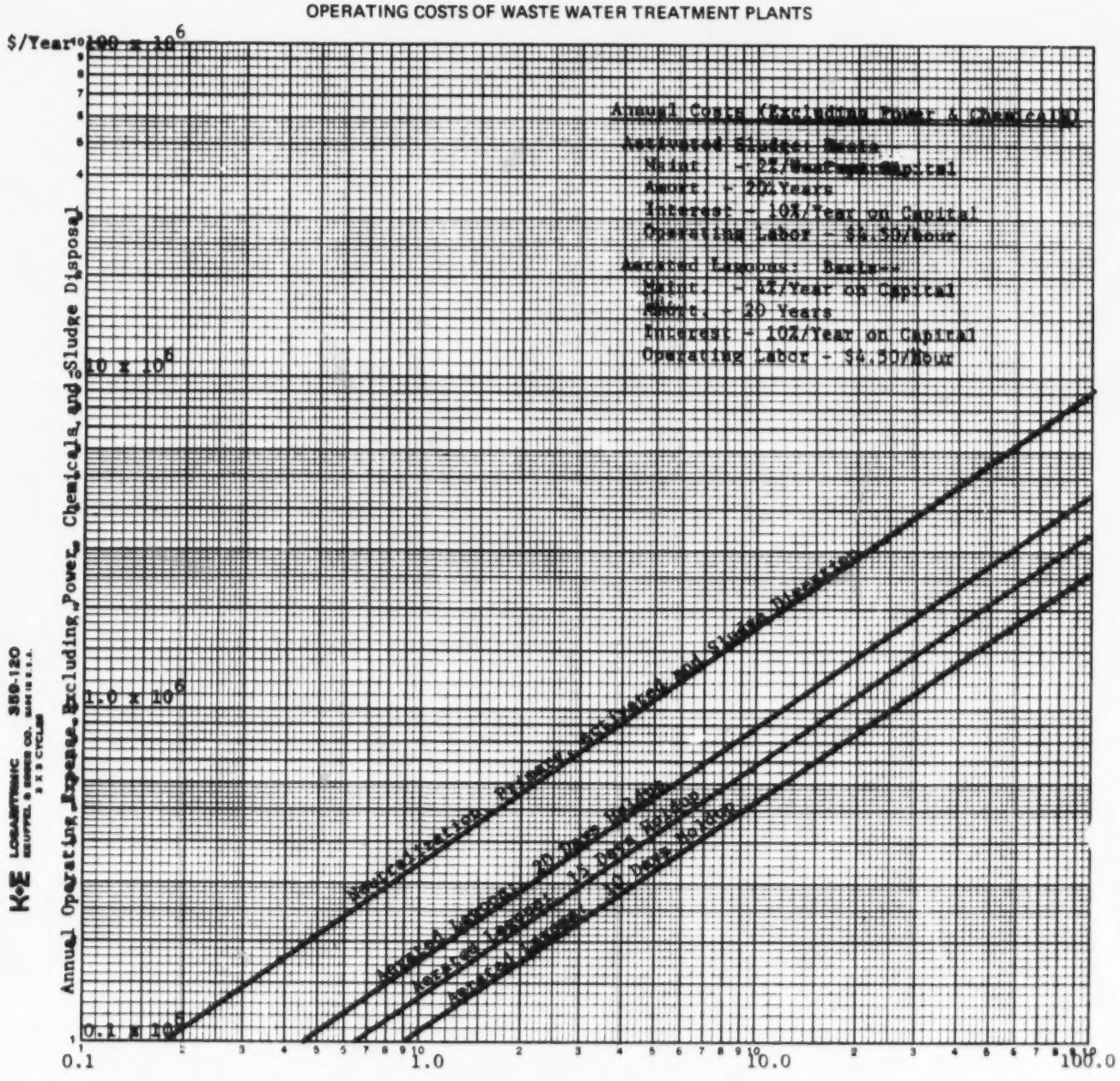
APPENDIX A

PRIMARY AND SECONDARY WATER TREATMENT COST ESTIMATING GRAPHS FOR PULP AND PAPER PRODUCTS

(except sulfite pulp)

FIGURE A-1

OPERATING COSTS OF WASTE WATER TREATMENT PLANTS



Untreated Effluent Flow - Millions of Gallons Per Day

Preceding page blank

FIGURE A-2

CAPITAL COSTS FOR AERATED LAGOONS

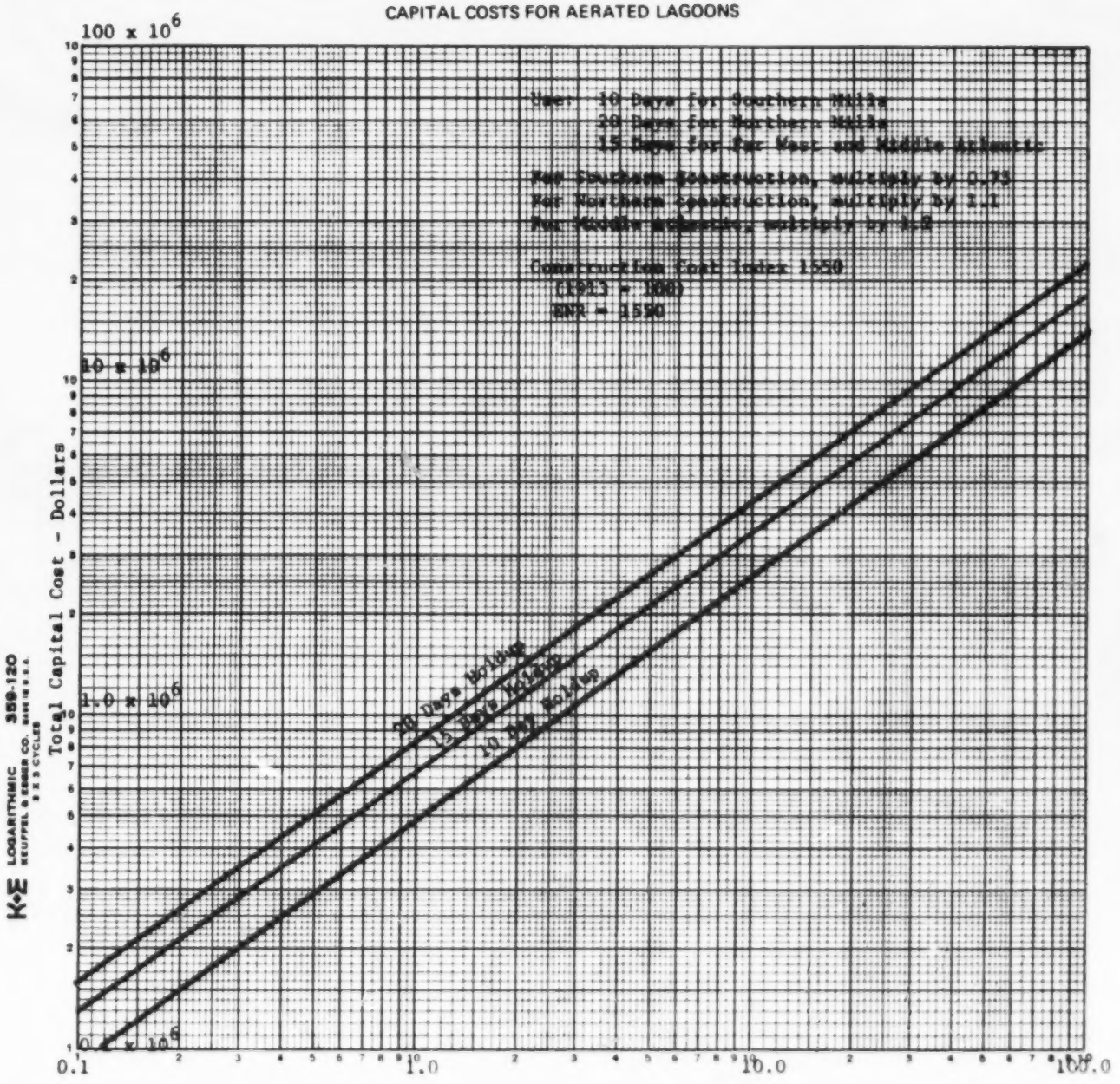


FIGURE A-3

CAPITAL COSTS FOR ACTIVATED SLUDGE SYSTEMS

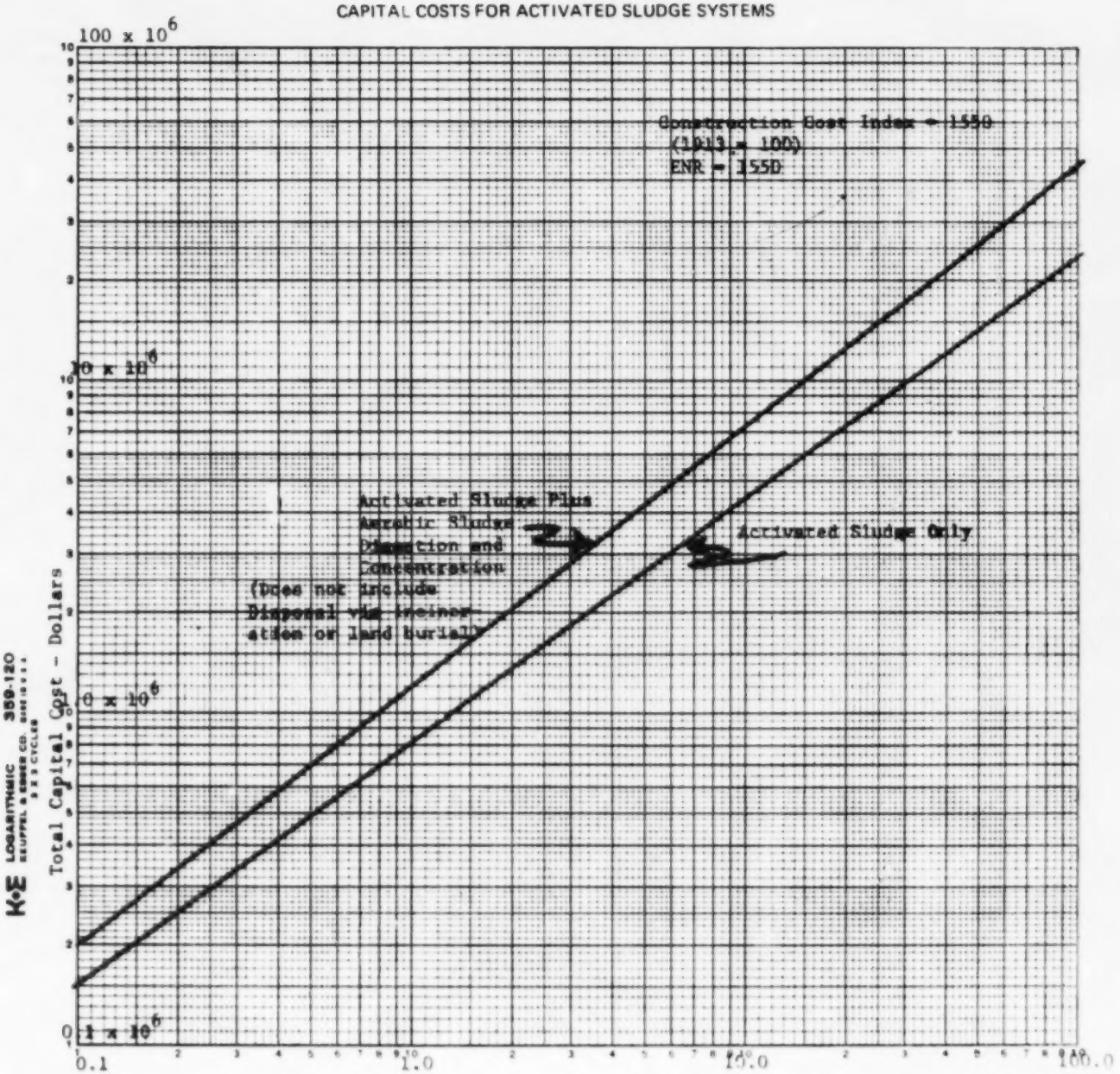
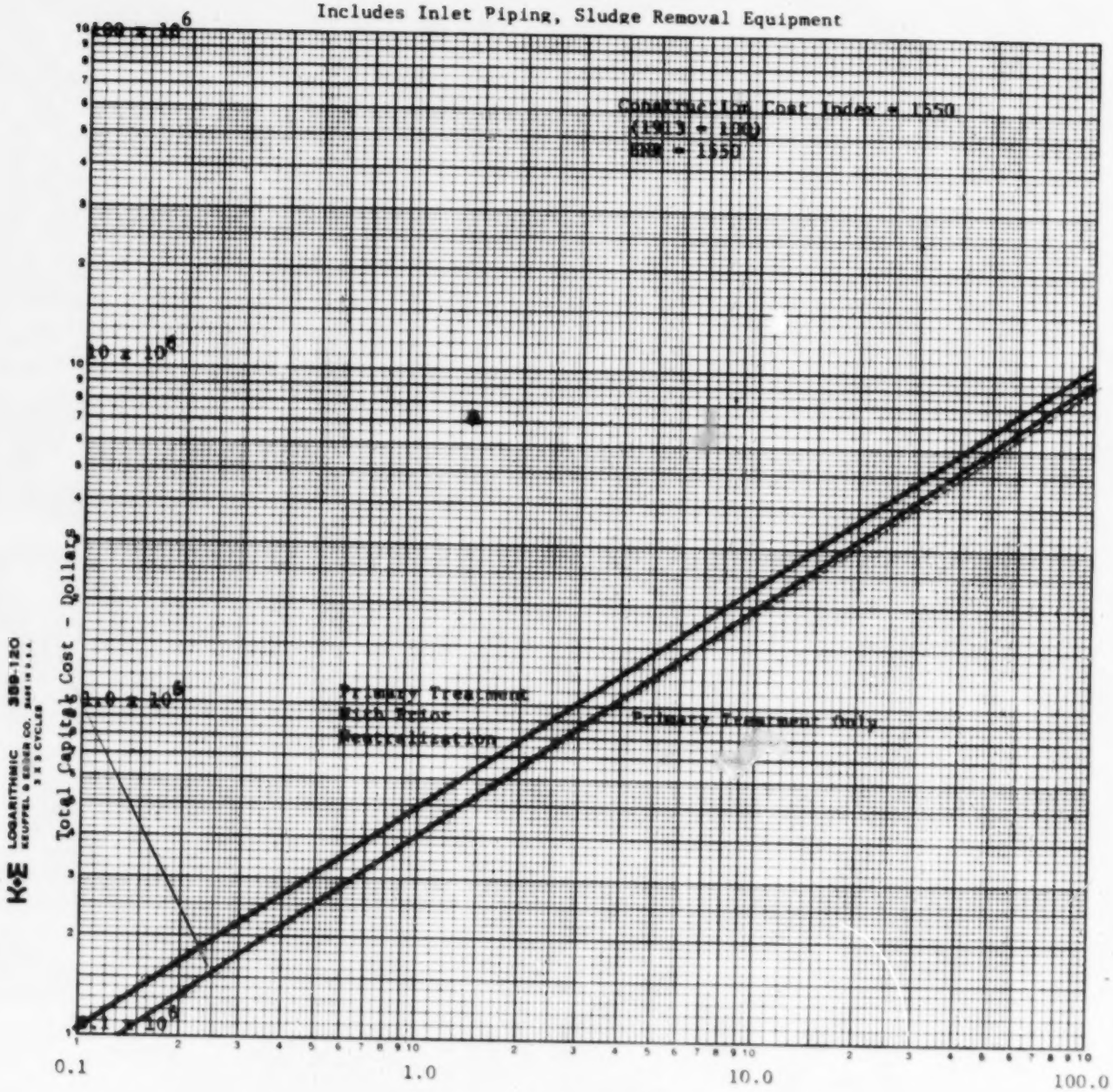


FIGURE A-4

CAPITAL COSTS FOR PRIMARY TREATMENT

Includes Inlet Piping, Sludge Removal Equipment

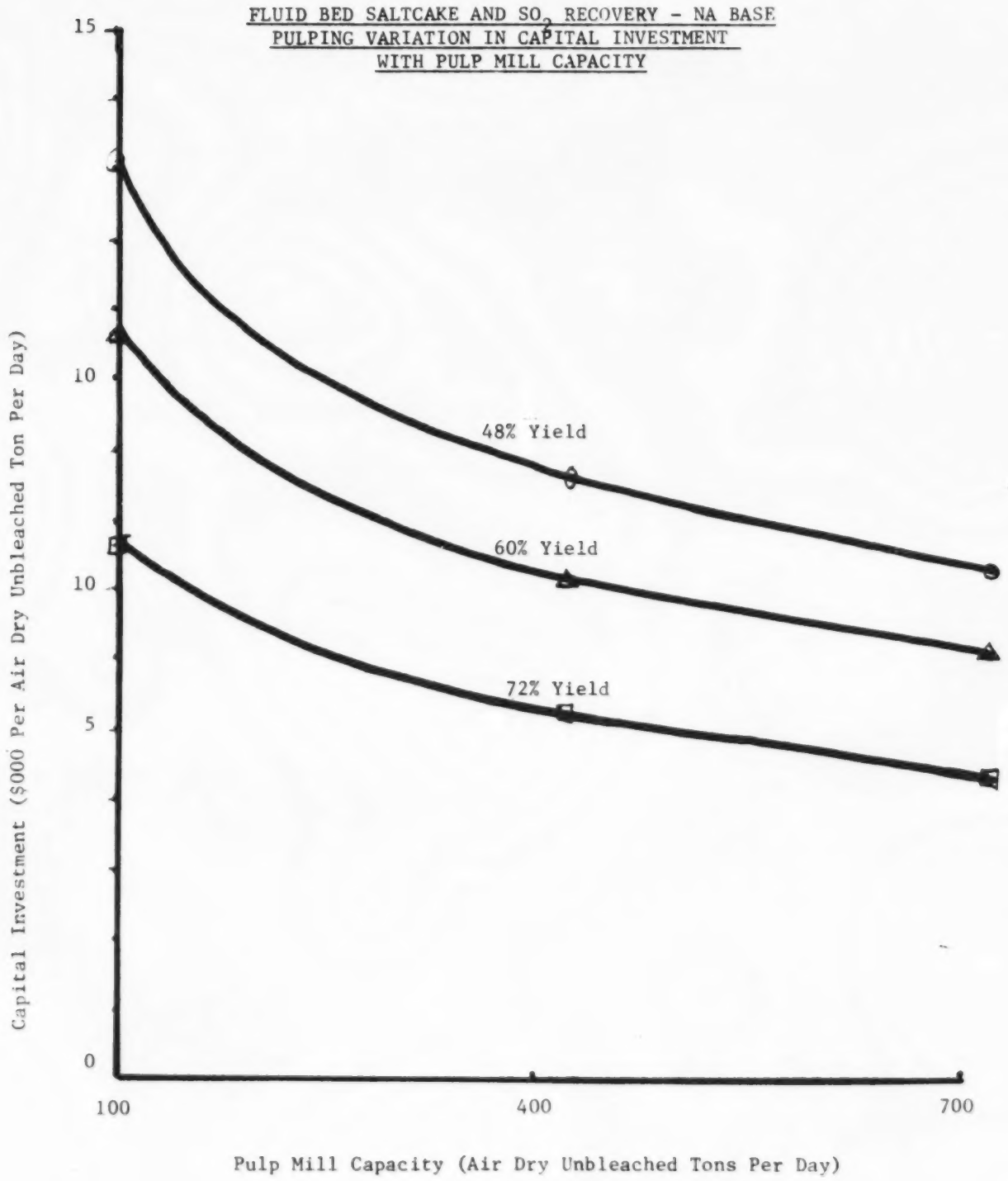


APPENDIX B

SULFITE PULP LIQUOR TREATMENT AND CHEMICAL RECOVERY SYSTEM

CAPITAL AND OPERATING COSTS

FIGURE B-1



Source: Arthur D. Little, Inc., estimates

Preceding page blank

FIGURE B-2

FLUID BED SALTCAKE AND SO_2 RECOVERY - NA BASE PULPING VARIATION IN OPERATING COST WITH PULP MILL CAPACITY

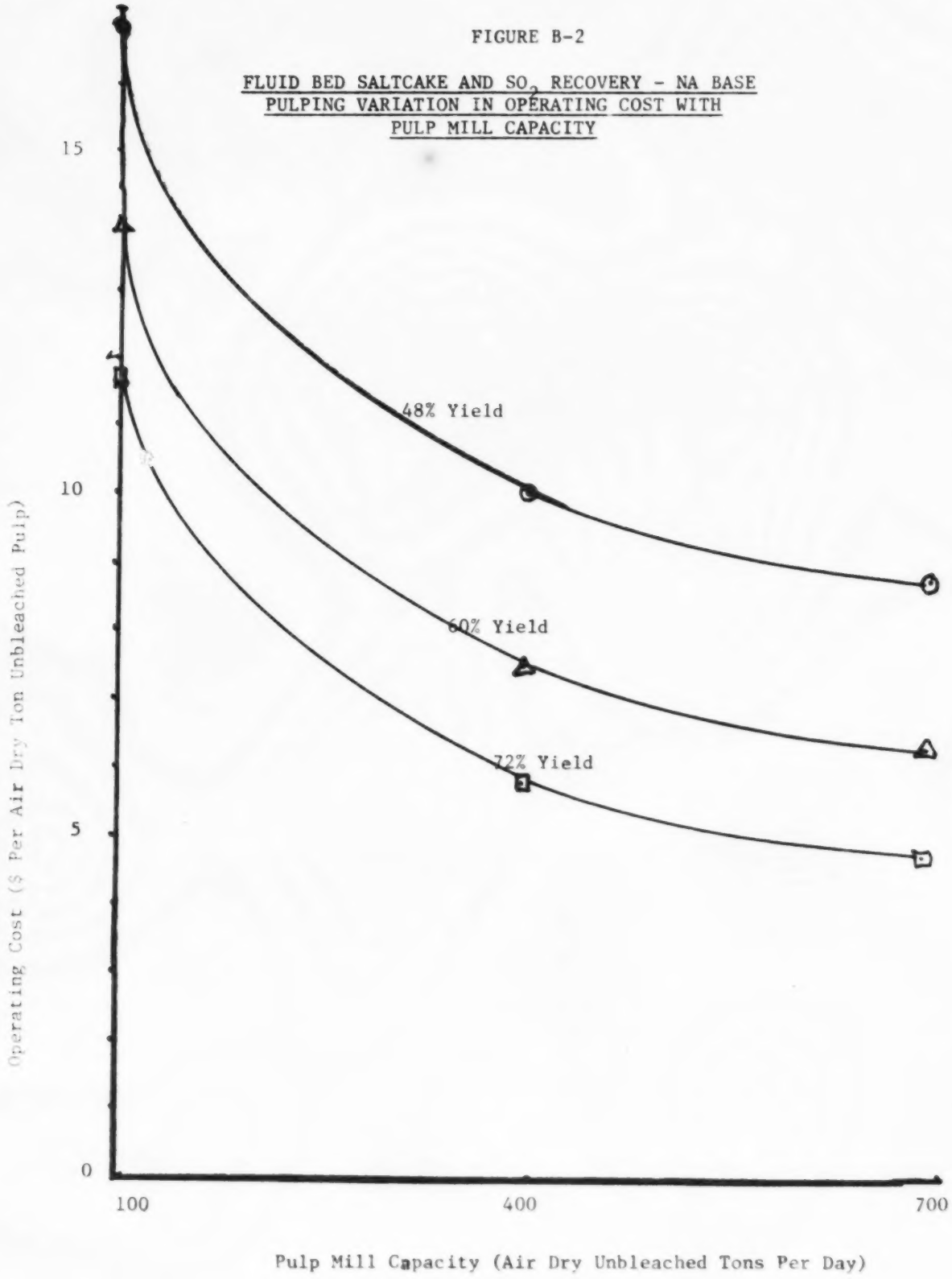


FIGURE B-3

EVAPORATION, BURNING AND SO_2 RECOVERY - NH_3 BASE PULPING
VARIATION IN CAPITAL INVESTMENT WITH PULP MILL CAPACITY

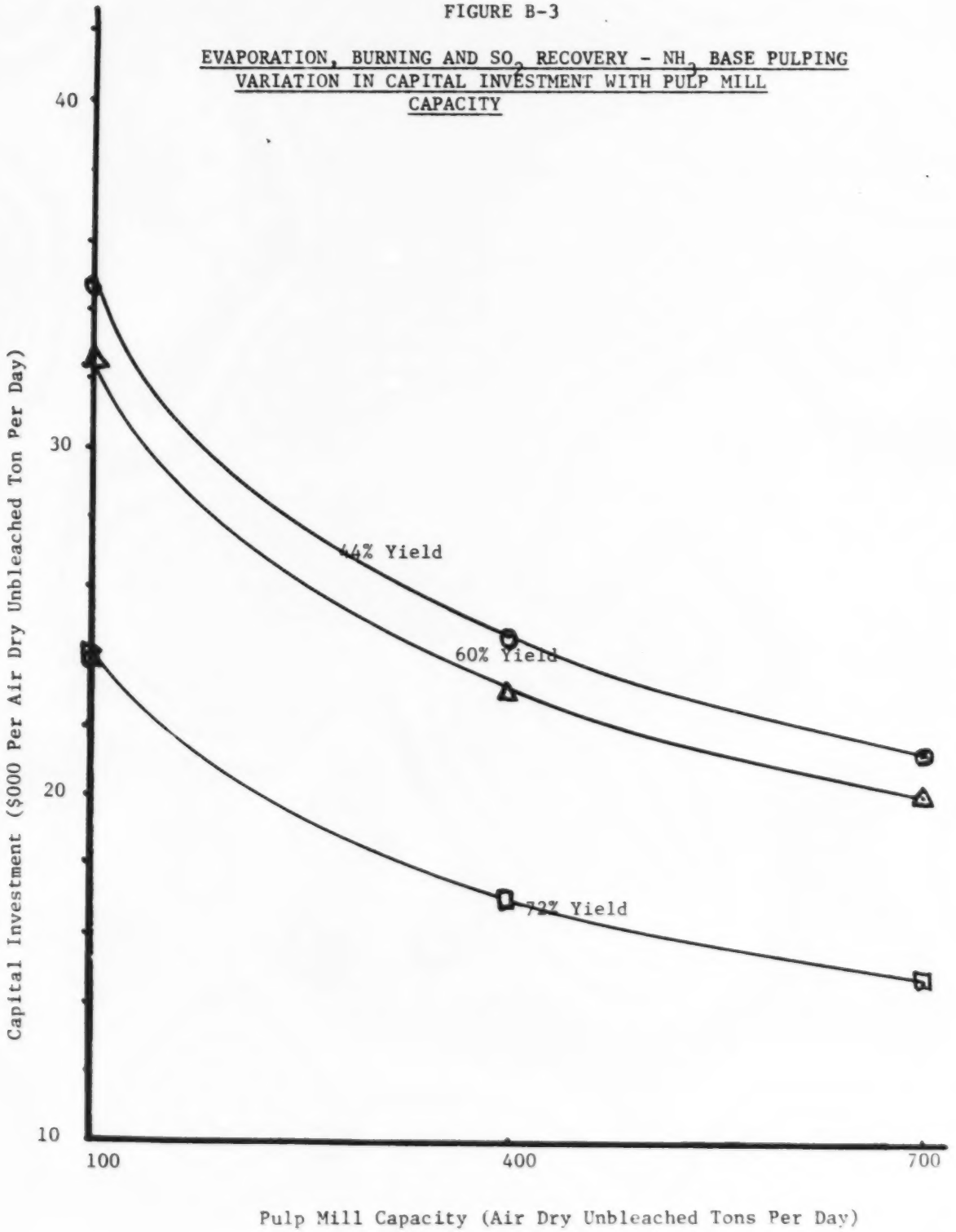
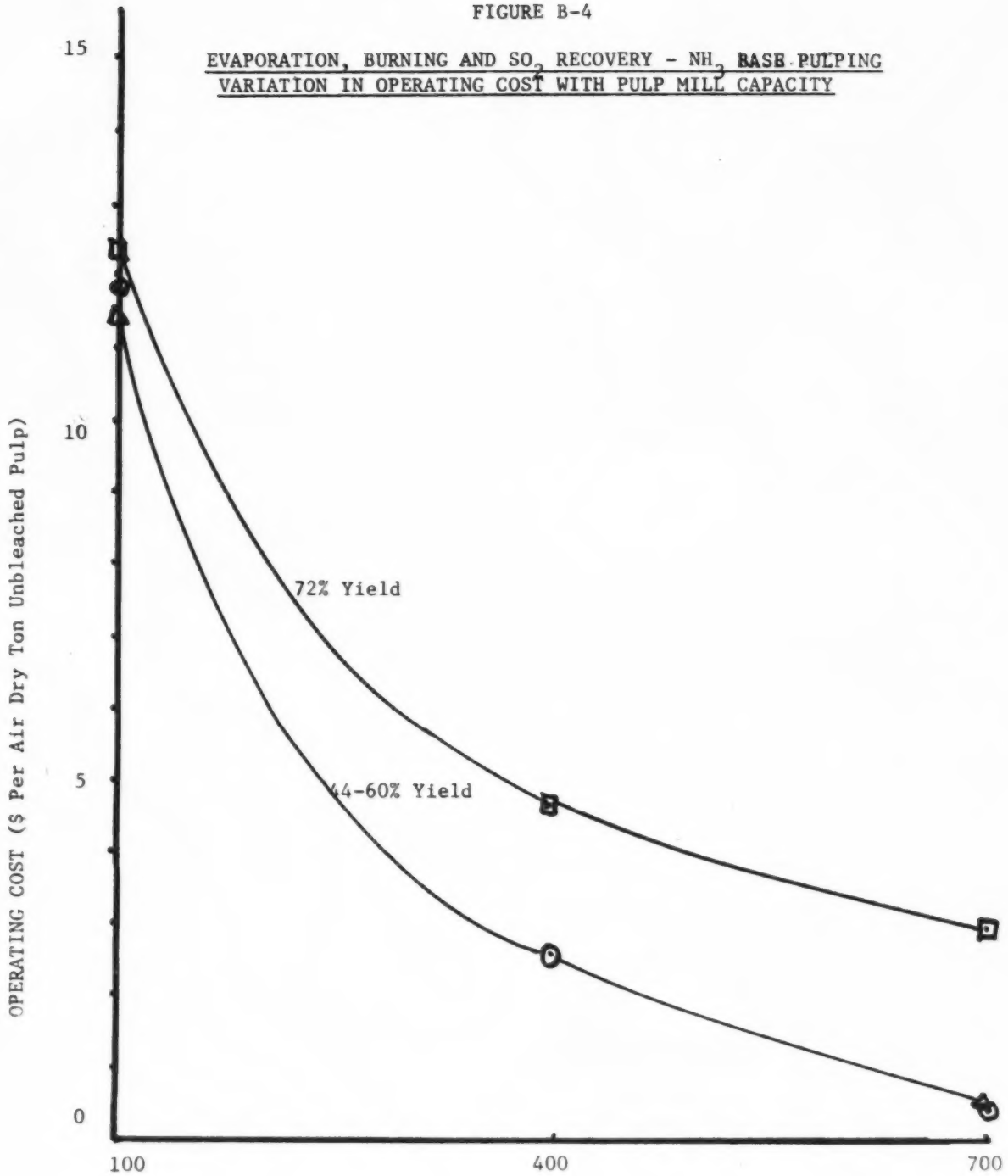


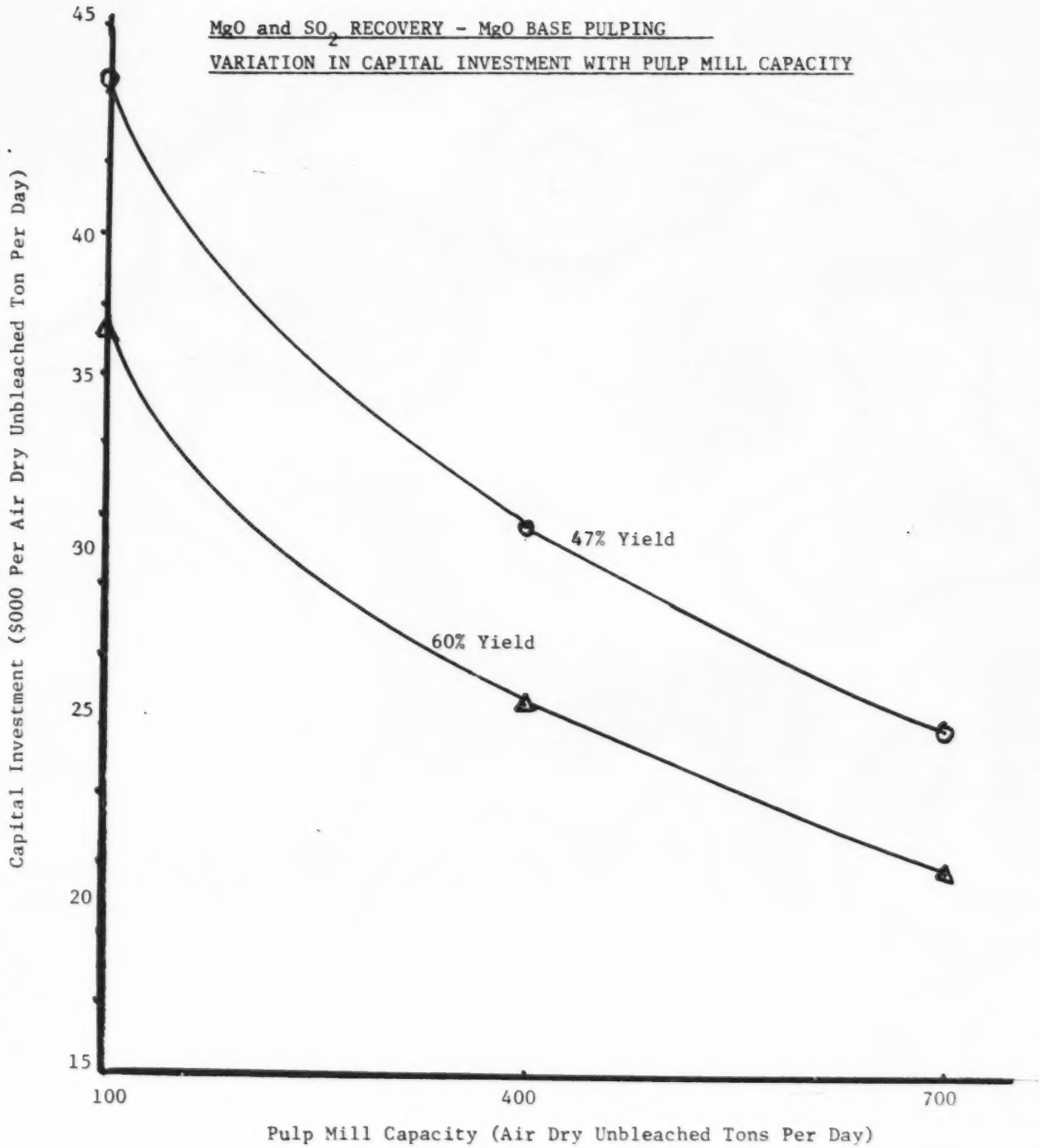
FIGURE B-4

EVAPORATION, BURNING AND SO_2 RECOVERY - NH_3 BASE PULPING
VARIATION IN OPERATING COST WITH PULP MILL CAPACITY



Source: Arthur D. Little, Inc., estimates

FIGURE B-5



Source: Arthur D. Little, Inc., estimates

Arthur D Little Inc

TABLE B-1

SULFITE PULP WASTE LIQUOR TREATMENT AND CHEMICAL RECOVERY SYSTEMS – CAPITAL AND OPERATING COSTS

Recovery System	Fluid Bed Incineration, Na_2SO_4 and SO_2 Recovery						Evaporation, Burning, SO_2 and Heat Recovery						Evaporation, Burning, SO_2, MgO, and Heat Recovery			
Pulping Base	Sodium	Sodium	Sodium	Sodium	Sodium	Sodium	Ammonia	Ammonia	Ammonia	Ammonia	Ammonia	Ammonia	Magnesium(5)	Magnesium(5)	Magnesium(6)	Magnesium(6)
Pulp Yield (%)	48	48	60	60	72	72	44	44	48	48	72	72	47	47	60	60
Pulp Mill Capacity (Tons/Day)	100	700	100	700	100	700	100	700	100	700	100	700	100	700	100	700
Days/Year Operation	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Plant Investment ($ Million)	1.1	4.3	0.9	3.6	0.7	2.6	3.0	13.0	2.8	12.2	2.1	9.0	3.9	15.6	3.2	13.0
Fixed Capital Investment ($ Million)	1.3	5.0	1.1	4.1	0.8	3.0	3.5	14.9	3.3	14.0	2.4	10.3	4.3	17.4	3.6	14.5
OPERATING COST ($ per Air Dry Ton Unbleached Pulp)																
Makeup Chemicals(1)																
Sulfur (Credit)	(2.20)	(2.20)	(1.40)	(1.40)	-	-	(3.29)	(3.29)	(3.06)	(3.06)	(0.99)	(0.99)	(4.14)	(4.14)	(1.29)	(1.29)
NH_3	-	-	-	-	-	-	0.75	0.75	0.70	0.70	0.25	0.25	-	-	-	-
$Mg(OH)_2$ (Credit)	-	-	-	-	-	-	-	-	-	-	-	-	(7.56)	(7.56)	(2.34)	(2.34)
Na_2SO_4 (Credit)	(0.92)	(0.92)	(0.83)	(0.83)	(1.00)	(1.00)	-	-	-	-	-	-	-	-	-	-
Bleach Chemicals	-	-	-	-	-	-	0.20	0.20	0.18	0.18	0.10	0.10	-	-	-	-
Utilities(2)																
Steam	5.75	5.75	3.80	3.80	2.32	2.32	(8.88)	(8.88)	(8.25)	(8.25)	(4.44)	(4.44)	(10.24)	(10.24)	(7.73)	(7.73)
Power	2.13	2.13	1.30	1.30	0.76	0.76	1.33	1.33	1.19	1.19	0.63	0.63	1.33	1.33	0.84	0.84
Labor & Fringe Benefits(3) ($5/hr +31% Operating Labor)	3.14	0.45	3.14	0.45	3.14	0.45	3.14	0.45	3.14	0.45	3.14	0.45	4.71	0.67	4.71	0.67
Factory Overhead (130% of Operating Labor)	3.14	0.45	3.14	0.45	3.14	0.45	3.14	0.45	3.14	0.45	3.14	0.45	4.71	0.67	4.71	0.67
Repair Labor & Materials (4% Plant Investment/Year)	1.25	0.72	1.06	0.59	0.74	0.42	3.46	2.13	3.23	1.99	2.40	1.47	4.43	2.56	3.69	2.13
Operating Supplies (0.25% Plant Investment/Year)	0.09	0.04	0.07	0.04	0.06	0.02	0.23	0.13	0.20	0.12	0.14	0.09	0.29	0.16	0.23	0.13
Property Taxes + Insurance (1.5% Plant Investment/Year)	0.49	0.26	0.40	0.22	0.29	0.16	1.29	0.80	1.20	0.75	0.89	0.55	1.66	0.96	1.37	0.80
Depreciation (6.5% Fixed Capital Investment)	2.17	1.32	1.97	1.09	1.40	0.78	6.46	3.96	6.03	3.71	4.46	2.74	8.03	4.63	6.71	3.86
Interest on Borrowed Funds(4) (4% Fixed Capital Investment/Year)	1.46	0.82	1.20	0.67	0.86	0.48	3.97	2.44	3.71	2.29	2.74	1.69	4.94	2.85	4.11	2.38
TOTAL OPERATING COST ($ per Air Dry Ton Unbleached Pulp)	$16.70	8.82	13.84	6.38	11.70	4.85	11.79	0.47	11.41	0.52	12.46	2.98	8.15	(8.12)	15.01	0.11

Notes: (1) F.O.B. Pulp Mill Chemical Prices: Sulfur $38 per 2000 lbs, NH_3 $50 per ton, $Mg(OH)_2$ $70 per ton, Na_2SO_4 $15 per ton
(2) Steam (Fuel) Credit $0.80 per Million Btu's, Steam Cost $0.95 per Million Btu's, Power Cost 7 mils per KwH
(3) For Sodium and Ammonia Base Recovery Systems, Operating Labor is 2 men per shift; for magnesium base, 3 men per shift
(4) 100% Fixed Capital Borrowed at 8% Interest Unpaid Balance
(5) Magnesium Acid Sulfite
(6) Magnefite (Bisulfite)

SOURCE: ARTHUR D. LITTLE, INC. ESTIMATES

Arthur D Little Inc